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ERRATA TO VOL. V.

Page 87, line 11, *for* M. Von Mons, *read* M. Van Mons.

91, line 15, *for* decompose, *read* precipitate.

54, line 6, from bottom, *for* $\frac{59}{1000000000}$, *read* $\frac{55}{100000000}$.

128, line 5, from bottom, *for* Coldle, *read* Cottle.

130, in fig. 2, *for* $b^{\frac{1}{2}}$, *read* $b^{\frac{1}{4}}$.

131, line 6, *for* as 13 to 15, *read* as 13 to 5.

233, line 17, and p. 235, line 14, *for* M. Encker, *read* M. Encke.

305, line 16, *for* the manner in which the chlorine lies in the water is evinced by, *read* is evinced by the manner in which the chlorine lies in the water.

306, line 22, *for* Asalaphus, *read* Ascalaphus.

line 29, *for* Taile, *read* Tailed.

line 30, *for* Fuvercœa agavephylla, *read* Furcrœa agavephylla.

line 32, *for* M. Felix de Avelear Protero, *read* M. Felix de Avellar Protero.

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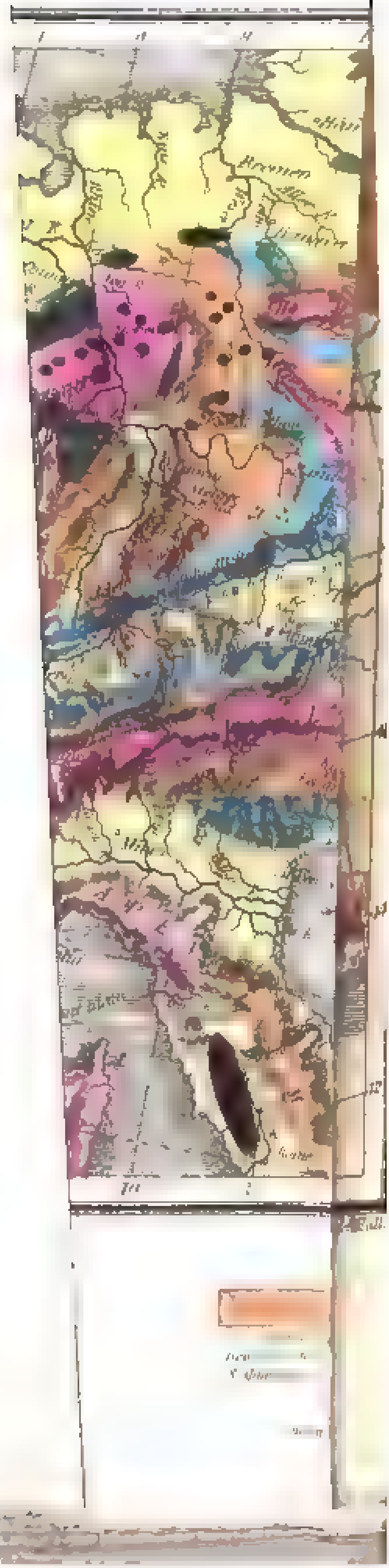


ANNALS

OF

PHILOSOPHY.

JANUARY, 1823.

Article I.

Memoir illustrative of a general Geological Map of the principal Mountain Chains of Europe. By the Rev. W. D. Conybeare, FRS. &c. (With a Plate.*)

(To the Editor of the *Annals of Philosophy.*)

SIR,

So rapid has been the progress of geological science within the last ten years (since its cultivators, abandoning the idle endeavour to construct theories without data, have confined themselves to the only true path of philosophy, that of inductive observation), that while at the beginning of this period, amidst volumes of speculation, no accurate description of a single country could be found, a physical map of the entire extent of Europe may now be confidently anticipated at no distant day. The labours of Buckland, Ebel, Freisleben, Raumer, and more especially the highly important work of Beudant† on Hungary, and the memoir of Mr. Strangways on Russia, have already accumulated a vast store of valuable materials, to which a few months will probably add a geological map of France by Omalius d'Halloy, and of Germany by Von Buch;‡ together, as it is

* The map is partly copied from one in Ebel's Bau die Erde.

† This is at present known in this country only by a few unconnected extracts; a full analysis ought to be given in some of our scientific journals. I have no hesitation in pronouncing it the most important geological work which continental science has yet produced.

‡ While this memoir was passing through the press, I have received the four first numbers of a very able geological work now publishing periodically in Germany by

hoped, with Charpentier's long-promised description of th Pyrenees. It is also understood that an individual in this coun try, eminently qualified for the task, has, for a considerable tim been employed in collecting together all the scattered sources information, with a view to incorporate them in a general map Europe.

In this advanced state of the science, a general *coup d'œil* c the ground which has been already gained seems desirable, an in this view I have thrown together the following brief notices embodying their contents in the accompanying map (Pl. XIX) in which, neglecting the detail (an object precluded both by the scale adopted, and by the yet incomplete state of the requisite observations), it is attempted alone to indicate the *general* distribution of the *principal classes* of European formations, and nothing further than *approximation* is professed. I shall be fully contented if this sketch may be considered as an humble but useful subsidiary to the more extended plans of which I have spoken; as an index map, it may, I hope, accomplish this purpose, for which its small scale particularly qualifies it, allowing the information it contains to be comprehended at a single glance; while those general relations which are the great objects of true science, and which are often almost lost amidst the complications of detail, are brought more prominently forward, and more readily seized under these circumstances.

The map on which these observations are laid down is copied as to its groundwork from a similar map in Ebel's work on the Alps, although the great advances in geology have required an almost total change in the colouring of the secondary countries, and many corrections in that of the older chains, so that in its present state, it may be considered as almost an original document. It will be found to include all those parts of Europe which are most important to the present object; since the southern extremities omitted (Spain, for instance), are generally as yet too imperfectly known to have admitted even an approximate representation; while the Scandinavian chains of the north (including almost the whole country north of the Baltic, as far as the gulf of Finland), presenting only primitive and transition rocks, are too uniform to require any.

The general distinctions which alone are attempted in this map reduce themselves to the following: 1. The more ancient rocks, including the primitive and transition classes. 2. The carboniferous series, including the old red sandstone, mountain limestone, and coal measures. 3. The new sandstone and mag-

C. Keferstein, the "Teutschland geognostisch geologisch dargestellt." This contains excellent introductory memoirs on the geology of Germany and the neighbouring countries; and it has greatly gratified me to find the plan of these memoirs nearly coincident with that adopted in the present paper. Maps and sections of Germany, Bavaria, Switzerland, and the Tyrol, have already appeared in this work; and I regard myself as fortunate in having been enabled to avail myself of these new materials in the accompanying map.

nesian limestone. 4. The lias and oolitic series (Jura limestone of the French). 5. Green sand. 6. Chalk. 7. Tertiary formations reposing on the chalk. 8. Overlying trap and volcanic districts.

I shall proceed to give a hasty sketch of the general distribution of these formations, following the order above specified.

1. *Primitive and Transition Districts.*

So intimate is the connexion between the schistose rocks of these two distinct æras (if distinct indeed they be, which some recent geologists appear strongly inclined to question), that it is impossible in any general map (unless the scale were such as to admit a separate colour for each individual rock), to assign any accurate line of division. In tracing, however, the tracts which fall under this description, I shall, as far as materials are afforded, and the nature of so general a sketch will admit, specify the leading character of the constituent formations.

Europe may be considered, when viewed under its most general aspect, as presenting a vast central basin occupied by the deposits of the secondary and tertiary class, surrounded by a border of alpine chains, exhibiting the older rocks of which we are now about to treat.

This border, however, is not continuous, but interrupted by openings, frequently very considerable, separating the constituent chains.

Neither is the included basin exclusively occupied by an uninterrupted series of the more recent deposits; but mountain groupes of the older rocks in places break through the mantle thus thrown over them, and reappear towering above the vicinity.

On the south of the great bounding chains, e. g. in Spain, Italy, &c. the same or similar secondary and tertiary deposits are repeated, forming portions of another great basin which may be designated as that of the Mediterranean.

There are other smaller and local basins comprehended by the tortuous course of the great chains.

The chains and groupes of the primitive mountains appear to present the centres of the greatest disturbances which have affected the surface of the earth, their strata being always elevated under high angles, often indeed in vertical planes, and exhibiting dislocations which can be referred to no cause but mechanical violence.

The extent of these disturbances appears often at least to be in proportion to the height of the chain; so that when the older chains form very elevated mountains (as in the Alps and Pyrenees), the secondary strata, and even those of very recent origin, are thrown into elevated planes, exhibit extraordinary contortions, and themselves form lofty collateral mountain ranges; but where, as in England, the older chains are compa-

ratively low, the secondary formations (those at least which succeed the carboniferous series), are nearly horizontal, and appear to have suffered little derangement, with a few local and limited exceptions, such as are presented by the vertical chalk, &c. of the Isle of Wight. The distinction, therefore, of inclined and horizontal, or floetz* rocks, does not express any inherent character in the rocks themselves, as deducible from their relative antiquity (any further than that the phenomena must induce us to consider the primitive chains as the scenes of the greatest and most general convulsions), but it depends merely on the circumstance of contiguity to the principal chains.

On the importance of these observations to geological theory, and the support they afford to the hypothesis of the elevation of the mountain chains, it is needless to insist.

I proceed to trace these principal chains in order, beginning from the north.

(A.) *Finland and Scandinavia.*

These countries, though not included in the map, must yet be noticed, in order to convey a complete idea of the chains bounding the great central basin of Europe.

They are almost exclusively occupied by primitive rocks, among which gneiss predominates, and characterises the lowest members. Granite is of less common occurrence, and alternates with the gneiss. Mica slate succeeds, on which granite again reposes. Transition rocks, principally limestone, containing the same organic remains with that of Dudley, in Staffordshire, skirt the primitive district on the southern shore of the gulf of Finland, in the Baltic islands of Gothland, Oeland, and Bornholm, and in the Scandinavian provinces of Gothland, Dalecarlia, Nerike, Jemtland, and the vicinity of Christiania; in the latter locality, a phenomenon of the greatest geological interest occurs; for here the transition limestone is covered by old? red sandstone conglomerate, on which reposes a porphyritic formation of various character, passing at one extremity into decided granite, possessing all the characters of that formation; and on the other, into basalt and wacke equally well marked. This repetition of granite as a comparatively recent formation covering those of transition, and its association with rocks, to which a great and increasing majority of geologists (increasing, it may be added, with the extension of the science itself, and almost with its existence as a science of accurate observation), concur in assigning an igneous origin, is one of the most important facts yet contributed towards the foundation of a secure theory.

* It has been objected to my remarks on the term floetz, as synonymous with horizontal, that it is really synonymous with stratified. I cannot, however, apprehend that it is used in the latter sense by the Wernerians; since in this case I must suppose them to apply as a distinguishing epithet to the secondary series, a character equally belonging to the majority of transition and primitive rocks; an absurdity which I do not wish to impute to them.

(B.) *Scotland—Ireland—England.*

The chains traversing the Shetland isles and the Scotch highlands and Hebribes, may be, perhaps, regarded as continuations of the Scandinavian range.

Mica slate is here the predominant rock: granite, however, forms the nucleus of several mountains. The phenomena exhibited by the junctions of the granite, and the veins sent off by it into the incumbent rocks, have been here minutely studied, and accurately described. The only writers who have yet given precise accounts of this district (Drs. Mac Culloch and Boué), concur in favouring the hypothesis which ascribes to the granite an igneous origin.*

A very narrow zone of transition slate separates this chain from the great central valley of Scotland occupied by the carboniferous series.

The highland chains of mica slate after expiring against the Irish channel in the peninsula of Kirtire, appear to be resumed on the opposite side in the north-east angle of Antrim; and though concealed for an interval by the overlying rocks of the basaltic area, re-emerge beyond them in the west of Derry, and occupy nearly the whole of Donegal, the structure of these countries exactly corresponding with that of the Scotch highlands. Donegal Bay for a time interrupts the continuity of the chain; but beyond that Bay, the primitive mountains of Sligo, Mayo, and Connemara, or Western Galway, must be regarded as its prolongation.

A second chain of mountains parallel to the former traverses the south of Scotland skirting on that side the great carboniferous valley, and forming the natural boundary between this country and England. It is known by the name of the lead hills in its central and highest part; the Pentlands, &c. forming branches of it. It consists principally of transition slate, through which granitic nuclei emerge in several groupes; and may be characterised from the northern chain by the absence of mica slate.

This chain also may be traced in its prolongation on the opposite coast of the Irish channel; its abrupted ends appearing on each side of the usual passage across that channel from Portpatrick to Donaghadee. In Ireland it extends from Down into Longford, retaining the characters already mentioned; the Mourne Mountains, a granitic nucleus, here constitute its principal summits.

The southern chains of Ireland may be more conveniently enumerated after those of Wales.

The small group of mountains containing the lakes of West-

* I desire to be here considered as only faithfully reporting the opinions of others, although I readily acknowledge myself strongly influenced by the concurrent testimony of almost every late and minute observer of such districts, and can hardly record their evidence without feeling myself convinced by it.

moreland and Cumberland is the next which presents itself advancing to the south. Granite is here of confined and limi occurrence; various rocks of the greenstone family and tran tion slate predominate; transition limestone occurs associat with the slate.

The central chain of the Isle of Man lying midway betwe this group and the Irish coast is also composed principally transition slate.

The mountains of North Wales, including the northern half South Wales, are like those of Cumberland, composed of tran tion slate, and many varieties of greenstone rocks.*

The Isle of Anglesea presents, in addition to these, chlor slate, serpentine, quartz rock, and granite. The granite described by Mr. Henslow, who has given a most elaborate a interesting account of this island as presenting the strong evidence of igneous origin; and having been formed, in o instance at least, by the fusion of old red sandstone *in situ*.

A zone of transition limestone skirts the east of the Wel chains in their course through Shropshire.

On the south-east of the Welch chains lies the detach group of the Malvern hills, consisting of a protruding range sienitic rocks flanked on the west by transition limestone, di ping rapidly in that direction, and appearing, according to M Horner, as if elevated by the protrusion of the sienitic mass which they repose.

In the centre of England another group of sienitic and gree stone rocks starts up in the midst of the secondary deposits co stituting the ranges and tors of Charnwood Forest, in Leiceste shire. The coal measures, &c. in approaching this group, a much disturbed and elevated. Some slate rocks here accompa the sienite.

The coasts of Ireland opposite to the Welch, to which we m next proceed, present in the Wicklow mountains a fuller develo ment of the usual primitive series, mica slate, gneiss, &c. than t chains last described. The granite here forms lower mountai principally on the western side of the chain, and extends into t plains at their base, mica slate constituting the loftiest summit Transition slate, greenstone, and quartz rock, occur on the eas ern border. This chain prolongs itself to the south-west throug Wexford, Cork, and Kerry, where it skirts the lakes of Killarne but in the two latter counties, transition rocks almost exclusive occupy it. Through its whole extent it forms a zone runnin parallel to the south-eastern and southern coast of Ireland; an it is a remarkable circumstance, that many rivers rising beyon

* I now use the term only as a general description of an extended class of rocks i Cader Idris, the Arrans, &c. and do not enter into the more minute details lately pu lished in the *Annals* concerning the Snowdonian range.

this zone in the interior cross its chains by transverse valleys in order to reach the sea. Such is the condition of the Barrow, the Suire, and the Blackwater.

The veins branching off from the granite of the Wicklow mountains are well displayed on the coast.

The eastern portion of these chains has been excellently described by Mr. Weaver.

The Ocrinian chain of Devonshire and Cornwall, is the last which remains to be noticed in the British isles. It extends from Exmoor to the Land's End. It exhibits, 1. A series of granitic nuclei, of which the loftiest and most extensive is the mountain plain of Dartmoor. The granite ramifies into the incumbent slates, and the slate for a short distance from its junction assumes an appearance approaching to gneiss, which the Huttonians have considered as an alteration induced by the contiguity of a heated mass. 2. Slates of a doubtful character and æra (that is, whether primitive or transition) succeed, abounding in metalliferous veins, and traversed by porphyritic dykes. 3. Slates decidedly of transition associated with granular greywacke, transition limestone and greenstone occupy the exterior of the groupe. Serpentine rocks also occur (in one tract very extensively) probably as members of the decided transition series. The Ocrinian chain, like those of England generally, is destitute of gneiss and mica slate.

Lundy Island, situated opposite the northern coast of this chain in the middle of the Bristol channel, is a mass of granite.

(C.) *Norman Isles, and North Western France.*

The Norman isles, which may almost be considered as a connecting link between the similarly constituted countries of Cornwall and the Cotentin, are principally granitic. 1. Guernsey presents granite and granitelle in the northern, and gneiss in the southern division. 2. Jersey in its higher and northern tract consists of granite, in its southern and lower of slate reposing on it. 3. Alderney has on the south-west cliffs of porphyry, on the north-east low shores of a grit formed from granitic detritus. 4. Sercq exhibits trap rocks on the west, and sienite on the south.—(See account of these isles by Dr. Mac Culloch, Geol. Trans. vol. i.)

Chains of Bretagne and La Vendee.—These appear in the nature of their constituent rocks and metalliferous deposits to bear a near resemblance to the Cornish chains. In the Cotentin the granite appears in some places decidedly to rest upon the clay slate; both these rocks *alternating* with quartz rock, porphyry, and sienite. Much, if not all, of this clay slate is evidently that of transition; in the shafts of the argentiferous lead mine of Huel Goat terebratulæ (spiriferæ?) have been found in it, and at Angers, trilobites occur. In La Vendee, the granitic rocks appear to predominate. A line drawn from Cherbourg by Alençon,

Angers, and Fontenay, to Sables d'Olonne, will indicate eastern boundary of those chains which extend westward to Atlantic. The Loire, however, breaks through their line in course to the sea, and where they open to give it passage, a sm coal basin reposes against them.

(D.) *Central Group of France.*

The primitive rocks, after plunging for a short interval bene the secondary calcareous beds, reappear in great force in central regions of France, constituting an extensive body mountains, sending out various ramifications between sources of the Loire, the Garonne, and their tributary strea being bounded on the east by the Rhone; and occupying greater portion of the departments, Haute Vienne, Creuse, C reze, Puy de Dome, Cantal, Loire, Haute Loire, Rhone, Lozer Viewed generally, this group presents a vast inclined plain risi gradually from NE to SW, in which last direction is principal and highest chain, that of the Cevennes. Gran is the predominant rock in this vast mountain plain, sla appearing to be of rare occurrence. In the departments Puy Dome, Cantal, Haute Loire, and Ardeche (including the ancie districts of Auvergne Forez Velay, and Vivarais), ridges a conical peaks of basalt, of Trachyte, and of volcanic scoriæ, superimposed on the elevated granitic plain, and constitute t loftiest summits of this group. Similar peaks are also scatter over the more recent deposits contiguous to the primitive chain Many of these peaks contain regular craters, and streams undoubted lava may be traced from them. Many of the valle descending from this mountain group contain deposits belongi to the coal formation reposing against the primitive chai sometimes also the tertiary deposits from upfillings in the valle The north-eastern branch of these ridges (called the Beaujol mountains) extends between the Loire and the Rhone as far the district of Morvan on the north of Autun, where the oolit chains of the Cotè d'Or overlie and abut against the granit The chains above described approach on the SE towards t Pyrenees, leaving but a narrow interval along which the gre Canal de Languedoc is conducted; but on the SW, the broa basin of the Garonne is interposed between them, exhibiting t regular series of secondary formations, from the new red sand stone to the tertiary beds.

(E.) *Pyrennees.*

The Pyrennees consist, according to Raymond, of five parall zones; namely, a central zone of granite bounded by two schi tose zones, which are in turn succeeded by the exterior calcar ous chains; the granitic axis, however, does not, as is usual mountain chains, form the loftiest crest; but, though towerin above the collateral chains on the side of France, is itself ove

topped by the schistose, and still more by the calcareous band on the side of Spain; the latter forming the Tours de Marbore, Mont Perdu, and all the loftiest summits of these mountains. What renders this circumstance more remarkable is, that this limestone appears from its organic remains, (Echini and Alcyonia), to be of comparatively recent formation. The specimens I have seen approach nearly to those varieties of the younger alpine limestone now generally considered as coeval with the green sand formation of England. I have been favoured with the sight of a very interesting letter from Dr. Bouè, who has recently examined this chain; he observes that it is entirely transition (transition slate and limestones, and marle), through which, in various places, granitic masses protrude, occasionally surrounded by gneiss and mica slate; these latter rocks appearing as they recede from the granite to pass into clay slate. He adds that the various phenomena which have been alleged in proof of the igneous origin of granite (granitic veins, fragments of slate imbedded in the granitic masses, the elevation, contortion, and dislocation, of the slates, together with their altered character near the point of contact, &c.), are here displayed on the most remarkable scale, and with a clearness of evidence nearly amounting to demonstration. He is even of opinion that the slates called primitive may, in this instance at least, have been only transition slates altered by the igneous influence; the transition limestone, in like manner, becomes converted into granular limestone in approaching the granite. Great dykes of greenstone and syenite also traverse the slate; when these are large, the limestones are in the same manner altered by their contact, and may be seen at Pousac elevated and supported by them. On the north of the Pyrennean chain old red sandstone and traces of mountain limestone occur, succeeded by new red sandstone with salt springs.

(F.) *Chains of the Middle Rhine, or the Vosges, the Black Forest, the Bergstrasse, or Odenwald, and the Spessart.*

Were we to pursue the course of the great chains forming the general boundary of the grand European basin, we ought, in the next place, to proceed to the Alps; but within the limits of this basin there are several protruding primitive groupes, skirting in places the course of the Rhine, and effecting a kind of subdivision between that part of the basin which lies in Northern France, and that of Central Germany. The first of these protruding groupes to be noticed are those which skirt the opposite sides of the great Valley of the Rhine in its central region below Basle; namely, the Vosges, which rise on the left bank of the river above Colmar and the Black Forest, or Schwartzwald, on the right bank.

The Vosges exhibit granite, transition slate, limestone, and porphyry. The greywacke near its contact with the porphyry

is, according to Dr. Boué, much altered, and the lime under the same circumstances, assumes a granular char Traces of coal occur on the borders of this chain in some p on the E and S, and a conglomerate, probably belonging t newer red sandstone, often overlies and abuts upon the prim rocks in surrounding the chain.

The intermediate Valley of the Rhine between these moun and the opposite group of the Black Forest, is principally c pied by formations of the tertiary order.

The Black Forest.—This range extends near the right ban the Rhine from Basle to Rastadt; it rises gradually from th and breaks down with a steep escarpment to the W. Gr is the prevailing rock, occasionally associated with gneiss. porphyritic formation sometimes rests on the granite, and fo summits. On the eastern slope, the range is covered by overlying red sandstone. The Odenwald rises in the prolo tion of the same line between Heidelberg and Darmstadt; constitution is exactly similar. The Spessart is a small i lated granitic group, almost close to the NE end of the Od wald.

(G.) *Chain of the Lower Rhine, or Slate Mountains of Ardennes, Eiffek, and Rhingau.*

This is a district of low mountains exclusively occupied transition rocks (i. e. greywacke, greywacke slate, and transit limestone), extending from the Meuse above its junction w the Sambre, across the Rhine below Mayence to Marburg. T chain is familiar to every continental traveller on account of magnificent defile which opens directly across it to give passa to the rapid waters of the Rhine between Bingen and Bonn; extensive and decided volcanic district partially overlies the tr sition rocks above Bonn. On the left bank of the river is region presenting plains covered with ashes, from which r some low but well defined craters; on the right are the trachy and basaltic summits of the Siebengeberge. This schist chain is skirted on the N by the formations of old red sandsto mountain limestone, and coal; on the S also, the mountain lim stone occasionally appears; but the new red sandstone genera overlies the transition rocks immediately.

(H.) *The Hartz.*

This is the last of the insulated and protruding groups we sh have occasion to notice.

It exhibits granitic summits: but no gneiss or mica slate h yet been found *in situ*. The granite is succeeded by clay slat and the usual transition series. The coal formation rests again the transition series, and is followed by the new red sandsto

conglomerate or rothe todteliegende,* on which the cupriferous slaty limestones, coeval with our magnesian series, repose.

(I.) *The Alps.*

Having surveyed the detached groups described in the preceding paragraphs, we may now resume our account of the principal chain, where it displays itself with the greatest magnificence in the colossal summits of the Alps: the older rocks constituting this chain first emerge from beneath the more recent calcareous chains of the Apennine in the north-west extremity of Italy. The first traces of the primitive rocks appear on the borders of Tuscany and Liguria. Serpentine is here the prevailing rock. In Tuscany this forms only low hills, but in Eastern Liguria, it constitutes the nucleus of the mountain chains, which are still called the Apennine. Gneiss and micaslate also occur; granite is rather rare, but beautiful varieties of primitive limestone are quarried in several places. It is not, however, till after passing Genoa that the name or character of the true Alps begins: here that portion of them called the Maritime Alps overhangs the coast of the Gulf. The primitive rocks appear to skirt the shore for about half the distance between Genoa and Nice, when

* All the maps and descriptions of the Hartz concur in proving this order of superposition (which has been controverted by Mr. Weaver), with regard to the *great and principal mass of the rothe todtliegende.* My high respect for my opponent in this controversy, and a general hatred of dispute, arising from reverence for the Baconian precept, "cordi et curæ sit non disputando adversarium sed opere naturam vincere," make me reluctant to misemploy my time in such discussions; but since a correct view of the relations of this rock forms an essential point in the identification of the British and continental series, I pledge myself in a short time to prove distinctively that Freisleben does expressly recognise the rothe todtliegende as a distinct formation from that of the carboniferous rocks; and to establish the superposition above given by copies of the maps and sections of the districts in which the rotheliegende occurs, pointing out at the same time the source of the confusion which has occurred.

From the perusal of Keferstein's memoirs on Germany, while this note was passing through the press, I find the most complete confirmation of this opinion; the rothliegende is uniformly described as *reposing* on the porphyry and coal formation. It is necessary, however, to advert to a source of confusion which might otherwise arise, from a mutual misconception of each others nomenclature, between the German and English geologists; the series of rocks being, as is agreed between both parties, 1. Coal. 2. Porphyry. 3. Red sandstone conglomerate (rothe todteliegende or rother sandstein); 4. Limestone representing geologically our magnesian lime (alpen kalkstein of Keferstein); 5. Variegated marle with salt and gyps (bunter sandstein). The English geologists have been in the habit of treating No. 3, 4, and 5, as included under one great formation, to which they have applied the name, new red sandstone, in order to distinguish it from the older quartzose conglomerate which underlies the great limestone formation supporting the coal, a rock, generally reckoned by the continental geologists (particularly by Raumer, and by Beudant in his excellent work on Hungary) among the transition series.

Hence the English writers use indifferently the same terms for the rother sandstein and the bunter sandstein—a circumstance which has led Keferstein in one instance to believe, that a difference as to fact existed between himself and Buckland, where in truth a difference of nomenclature was alone concerned.

In England, the magnesian limestone being of limited occurrence, this mode of viewing the subject is sufficiently precise; but it will be necessary in order to prevent the recurrence of these misunderstandings to harmonize for the future with the German writers, and to speak of the three formations as distinct, though yet as appertaining to one great order, that, namely, of the newer or saliferous sandstone.

they trend inland, and are succeeded by secondary hills. Alps, which may be said to expire on the side of Italy, a rather to be continued as to their geological constitution primitive chains of Corsica and Sardinia, situated directly site the termination of the Maritime Alps against the coast in the line of their prolongation.

From the Gulf of Genoa, the Alps pursue their course fi the NNW, through Piedmont and Savoy; then turning sud to the E through Swisserland, the Tyrol, and Stiria. The prir and transition chains have together an average breadt between 50 and 60 miles. These are succeeded by ex zones of limestone, principally coeval with the magnesian stone and oolitic series, the carboniferous series being appar absent,* or at most of very limited occurrence. The beds c Alpine rocks where these are stratified are generally vert the bordering chains exhibit marks of the greatest disturbа their strata being contorted and dislocated. Thus on the r all the recent calcareous chains appear to dip towards, ins of rising against, the central and primitive ridges. The t following sections taken from Ebel will give a general ide the distribution of the older rocks in the Swiss portion of Alps:

1. *Over the Bonhomme and Mount Cenis.*

Clayslate (Sallenche).
Micaslate and gneiss.
Primitive limestone and clayslate.
Gneiss, granite, micaslate, hornblende slate (the Bonhomme).
Primitive limestone.
Gneiss and micaslate.
Primitive limestone and gypsum.
Unexplored interval along the upper valley of the Isere.
Primitive limestone and gypsum.
Primitive limestone and micaslate (Mount Cenis).
Gneiss.
Clayslate.
Serpentine.
Granite.
Serpentine.

2. *Over Great St. Bernhard.*

Compact felspar and slaty sienite.
Greywacke slate.
Compact felspar and slaty sienite.

* Mr. de la Beche has, however, noticed traces of the coal formation in the Col Baume.

Primitive limestone.
Micaslate and granite
Primitive limestone and gypsum.
Gneiss.
Primitive limestone.
Gneiss and micaslate (Great St. Bernhard).
Primitive limestone and micaslate.
Primitive limestone and talcose rocks.
Gneiss.
Primitive limestone.
Hornblende, slate, and serpentine.

3. *Over St. Gothard.*

Gneiss.
Gneiss and granite.
Primitive limestone and gypsum.
Gneiss, granite, and micaslate (St. Gothard).
Hornblende, slate, and greenstone.
Primitive limestone and gypsum.
Gneiss.
Granite and gneiss.
Micaslate.

According to Ebel's map, the transition formations, greywacke, greywacke slate, and transition limestone, form a band of small comparative extent on the north of the Alps, the rest of the chain being primitive; but, according to D'Aubuisson, Mr. Brochant considers much of the gneiss, micaslate, and serpentine, of the Alpine chains, as truly belonging to the transition series: the details are given in the subjoined note.*

* M. Brochant, Professeur de Minéralogie et de Géologie à l'Ecole des Mines, alors établie à Moutiers, dans la Tarentaise, en observant divers points de cette contrée, fut frappé de la multitude de brèches et de poudingues qui s'y trouvaient; il vit les roches de ces montagnes alterner avec ces poudingues, et avec un terrain anthraciteux contenant des empreintes végétales. Il exposa ces faits dans un mémoire qu'il publia en 1808, et dans lequel on nous montra, pour la première fois, des schistes-micacés, des serpentines, des quartz en roche et des calcaires grenus, hors de la classe des terrains primitifs, et postérieurs à l'existence des êtres organisés. Ce mémoire classique et fondamental, pour employer les expressions de M. de Buch, fait époque dans cette partie de la science."

"M. Brochant a poursuivi, dans les Alpes qui avoisinent la Tarentaise, les conquêtes qu'il venait de faire aux formations intermédiares, et il ne s'est arrêté que devant le Mont-Blanc et les Grandes-Alpes, *retenu par un reste de considération pour leur ancienne prérogative de primordialité*, et par cette élévation qui les place au premier rang parmi les montagnes de l'Europe: mais sans désespérer qu'un jour de nouvelles découvertes ou de nouvelles analogies ne les fissent passer dans les terrains intermédiares; et en remarquant formellement que lors même que ces hautes Alpes appartiendraient aux terrains primitifs, elles n'étaient séparées, par aucune interruption, du terrain intermédiare de la Savoie, et qu'il y avait continuité entre la formation de ces deux terrains: conclusion très-importante, et sur laquelle nous avons déjà insisté.

"Je remarquerai ici que lorsqu'en 1807, M. Brochant fit le mémoire dont les conséquences ont été adoptées par tous les minéralogistes, ce savant manquait encore d'une partie des preuves qui les rendent aujourd'hui incontestables; alors on n'avait pas encore trouvé des coquilles dans les calcaires de la Tarentaise."

"Depuis les observations de M. de Brochant, dit M. de Buch, je commence à croire

In this map also a double zone of primitive limestone is rep sented pursuing its course with undeviating regularity on eit side the axis of the chain. In the Tyrol, the secondary lin stones encroach more on the primitive chains, which, thou still of considerable height, are tame in their features, and more than rivalled in elevation, and far surpassed in grande by the oolitic ranges.

The steepest escarpment of the Alps is uniformly towards Italian side.

(K.) *Chains surrounding the Basin of Bohemia, including Bohemer Wald, the Thuringer Wald, the Erzegebirge, Reisengeberge, and the Sudetengeberge.*

The central line of the Alps may, perhaps, be considered prolonged by the primitive chain, which passes from Presburg join the Carpathians; but on the NW of this line is a vast gro of ancient chains, extending between Vienna and Dresden, co pletely enclosing the sources of the Elbe, or the great basin Bohemia, and thus forming, as it were, a detached ring in fro of the general system. The Bohemer Wald, or branches co nected with it, closes this basin on the SW and SE, rangir round the sources of the Elbe. On the NW border, claysla alternating with greenstone rocks prevails; but in the rest the chain, granitic rocks predominate.

The Fichtelgeberge connects this side of the Bohemer Wa with the Thuringer Wald: it exhibits granitic summits skirte by clayslate and greenstone. The slate district is very extensi on the N.

The Thuringerwald (a branch extending from the NW of th primitive circle) exhibits granite, gneiss, and micaslate, skirte on the S by the overlying deposits of rothe todteliegende an cupriferous slaty limestone (our new red conglomerate, an magnesian limestone series). On the N, porphyritic rocks ove lying those of the coal formation occur.

que le gneis même, entre Martigny et Saint-Maurice, que tous les singuliers poudingu de la vallée de Triant jusqu'à Valorsine, que les rochers de gneis entre Martigny et Sain Branchies, appartiennent au terrain de *grauwacke*, et ne sont pas primitifs. Ces roch se retrouvent dans tout le Valais, quoique sans poudingues."

The slate of Glaris, containing fish and turtles, which has sometimes been consider as transition, appears rather to belong to the secondary rocks.

I am desirous to avail myself of this opportunity to correct an error I have inadve tently committed in quoting a statement of Dr. Mac Culloch's on a subject nearly co nected with this. In noticing his discovery of a calcareous formation containing organ remains underlying the gneiss, I have hastily used the term gryphite limestone, but th fossils observed were really orthoceratites: the whole sentence is also expressed too gen rally, and without sufficient precision. Instead of the brief clause "a gryphite lim stone underlying gneiss in one of the Hebrides," I ought to have written "a limeston formation underlying gneiss in Garvagh, the most northerly of the Hebrides, and i the shores of Loch Eribol on the adjoining main land, which at Eribol contains a subo dinate bed of calcareous sandstone, exhibiting traces of orthoceratites." The Doctor ha little doubt that the associated beds of the limestone will also be found to contain simila remains both at Eribol and in Garragh Island.

The Erzegeberge (forming the NW border of the Bohemian basin) presents the same primitive rocks skirted by the transition series. Its ridge supports in many places insulated basaltic summits, which are also abundant on the Bohemian side, where in the Mittelwald between the Erzegeberge and the Eger, they repose on tertiary deposits containing lignite. Porphyritic rocks overlying coal abound on the N of this chain as in the Thuringerwald.

The Riesengeberge (a continuation of the Erzegeberge on the opposite side of the Elbe, forming the north-eastern border of the Bohemian basin) has a central granitic axis, skirted by gneiss sometimes including micaslate, by clayslate, and lastly, by transition rocks; The gneissy zone is most extensive on the north, and that of clayslate on the south, of the central range. Beyond the valley of the Neisse, the continuation of this chain (here principally composed of clayslate), assumes the name of the Sudetengeberge, and ranging round the district of Glatz, unites itself with the slaty ridges proceeding from the Bohemerwald, thus completing the enclosure of the Bohemian basin (which, as we shall hereafter see, is occupied by the carboniferous series, new red sandstone, tertiary, and basaltic formations). The Valley of the Oder on the north, and of Moravia on the south, separate these chains from those of the prolongation of Alps towards the Carpathians ranging by Presburg.

(L.) *Carpathian Mountains.*

These mountains range in a semicircle round Hungary from Presburg, on the W, to the neighbourhood of Belgrade on the E; the ancient rocks, however, are not exhibited on the surface throughout the whole of this semicircle, there being an interval near the middle of its course (above the sources of the river Theiss) in which the older rocks only appear in patches bursting through an overlying sandstone deposit. With this exception, however, which does not amount to more than a sixth part of the whole semicircular range, the older formations are uninterrupted. They present first a central granite, then granite, gneiss, and micaslate, alternating together. 3. Micaslate and clayslate containing granular limestone. 4. Serpentine diallage rock (Euphotide) and greenstone porphyry. 5. Transition rocks.

Having enclosed Transylvania by a rapid bend, the primitive chain crosses the Danube below Belgrade.

It then appears to extend itself to the S, turning round to the E, and forming the chain of the Balkan or Mount Hæmus.

(M.) *Mount Balkan or Hæmus.*

I am not acquainted with any geological description of this chain. Macmichael, however, observes, in crossing it from

Gablova to Shipka, that the strata on the N are generally reous, and the summit a blue or variegated marble; but descent, the rocks change to a hard argillaceous schist, a ing in large veins of quartz.

On the S of the Crimea is a tract of slate which may be longation of this chain.

(N.) *The Range of Caucasus.*

This, though beyond the limits of Europe, is nece included in our present survey, being placed exactly on th longation of the line of Mount Balkan, and of the slat of the Crimea, of which it, therefore, appears to be the tinuation, forming with it the southern border of the European basin. It is said to exhibit the usual primitiv transition rocks skirted by compact limestone, and to e near its centre some overlying summits of floetz trap.

(O.) *Granite Plains of the Dnieper.*

These appear to constitute a group of primitive rocks pro ing through the secondary and tertiary deposits of the basin: granite principally prevails, and the country is char rised by the unusual circumstance, that although of prim structure, it is yet low, and, except where furrowed by the va of the rivers traversing it, level.

(P.) *The Ural Chain.*

The great European basin is open through a wide inte destitute of any primitive barrier towards the Caspian and Whether any primitive zone exists behind these inland seas how far the secondary deposits extend in this direction into A is unknown; but on the NE, the Ural Mountains on the fines of Europe and Asia again present a primitive border, e biting, according to Pallas, the usual central and collateral zo of ancient mountain chains. It seems probable, but has no believe, been ascertained, that the primitive rocks of Finland the north of the great basin extend along the shores of White Sea till they join the northern extremity of the chain, thus completing the primitive margin of the basin on side.

(*To be continued.*)

Article II.

On Fossil Human Bones, and other Animal Remains recently found in Germany. By Thomas Weaver, Esq. MRIA. MRDS. MWS. MGS.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Tortworth, Wotton-under-edge, Dec. 7, 1822.*

The admirable paper of Prof. Buckland on fossil teeth and bones, discovered in caves and diluvian gravel, in England and on the Continent,* has excited, as might have been expected, a high degree of interest in the public mind. Persuaded of the value attached to every addition to our stock of knowledge, that may tend in any measure to elucidate the effects of diluvian or post-diluvian action, it appeared to me that an acceptable service might be performed, by conveying to the English reader an account of the fossil human remains lately discovered in Germany, in company with those of other animals, near the valley of the Elster. The facts detailed, and the speculations thence arising, which proceed from the pen of the Baron von Schlotheim, are contained in the following paper, to which I have added a few notes. You will favour me by inserting it in the *Annals of Philosophy*; and I am, Sir,

Your most obedient servant,

T. Weaver.

Geological Description of the Environs of Köstritz, with an Account of the Fossil Bones discovered in that Vicinity.†

The recent discovery of human bones, as well as those of other animals, in a fossil state, in the neighbourhood of Köstritz, cannot fail to render a description of that district interesting to naturalists in general.

I had an opportunity of examining that part of the country this spring (1820), in company with Mr. Braun, Counsellor to the Land-Chamber, a gentleman distinguished by his exact mineralogical knowledge. Its geological relations are so well exposed in the ranges of hills, and in the quarries opened on their declivities, that no room is left to doubt the disposition and order of succession of the different floetz formations, which appear in that vicinity.

The valley of the Elster extends from Köstritz to the N, in an average breadth of about $2\frac{1}{4}$ English miles, flanked by heights which are covered with fertile fields, and slightly wooded. These eminences form connected ranges on both banks of the

* Published in the Philosophical Transactions for 1822, Part I; and also in the *Annals of Philosophy* for August and September, 1822.

† From the Introduction to the Petrefactenkunde of the Baron von Schlotheim. Gotha. 1820.

Elster, passing Politz and Kaschwitz; that on the E, near obtaining the greatest elevation. The bottom of the valle is perfectly smooth, refreshing the eye with its verdan dows, diversified with groups of trees, from among whicl villages and mills. From the heights above, an ext varied, and very agreeable prospect may be enjoyed, parti toward the N in the direction of Gera.

The foundation upon which the floetz formations repos sists of transition reddish-grey clayslate, and firm fine-g greywacke. The former may be seen in the valley of Ele ranging 30° E of S, and W of N, and dipping 70° — 75° NE. It rests on the greywacke, which first appears l Köstritz, rising further S into a considerable cliff, and ex ing in this quarter traces of old mining works. Lamelli phate of barytes, with disseminated malachite, occurs in the old hillocks. The clayslate is immediately covered l older floetz limestone,* which rests upon it in an uncon able, and nearly horizontal position. The lowest strata are s and occasionally somewhat bituminous; but in some p where they nearly adjoin the clayslate, they are also micac and of a smoke-grey colour (belonging to the so-called zech or argillaceous limestone), and are traversed by small vein fissures, which contain galena. In the upper strata, the mica, and bitumen, disappear entirely, and, in their stead, t of yellow ochraceous ironstone become visible.

All these appearances are very common in this formati limestone. We no where observed, in the places we exam the bituminous or cupriferous marl shale, nor the todtlieg Both appear to be wanting in the vicinity of Köstritz, an latter first occurs between Gera and Pforten, where it is exhi in all its varieties.†

The limestone, just described, ranges principally on the bank of the Elster toward Gera, as far as the vicinity of I mannsdorf, and again on the right bank near Politz, where well displayed in several quarries. On the other hand, the sum, which is imbedded in, and subordinate to, this limest

* The older floetz limestone of the Baron von Schlotheim, noticed above is the as the lower floetz limestone formation of Germany described by Freiesleben, th floetz limestone of Werner, the equivalent of what has been called the magnesian stone formation of England; in illustration of which, see my papers in the *Ann Philosophy*, for October, November, and December, 1821; and August, 1822.—

† The meaning attached by the Baron von Schlotheim to the term todtliegen consistent with that of German writers in general. In the restrictive sense, it si the old red sandstone; in the enlarged, it comprehends the coal formation als proof of which it may be sufficient to refer to the Petrefactenkunde, Introduction and 6, where the author observes, "Certain petrifactions are found in the *coal san and slate clay that are subordinate to the todtliegende, or older floetz sandstone*,' again in p. 385, of the work, "In a general point of view, petrified wood may b to be of rare occurrence in *the coal measures of the older sandstone formation*, as w in coal formations of more recent origin." I should hardly have thought it nece to advert to this construction of the term todtliegende, had it not been lately c asserted.—(See also my Geological Remarks in the *Annals of Philosophy*, for Au 1822.) I may here observe that todtliegende, rothliegende, and rothe todtliegend synonymous terms with German authors.—T. W.

occurs at the foot of the opposite range, on the W, near Köstritz and Kaschwitz, in the same manner as it appears near Tieschütz, not far from Hartmannsdorf, in the whole of which extent the numerous gypsum quarries afford an insight into its character. The depressions and sinkings of the earth which occur in the vicinity, proclaim that we have entered upon the domain of the cavernous gypsum and limestone, the latter of which is, as usual, covered by the variegated or new red sandstone formation, which appears near Hartmannsdorf, and on the ridge of the chain of heights near Politz. Over the whole of these floetz formations is spread an alluvial loamy tract, which is sometimes sandy, extends for many miles, and yields to the landholder a rich return when duly cultivated.*

After this concise general view of the country, and of the order and succession of the floetz formations, appearing near Köstritz, I now proceed to a nearer description of the limestone and gypsum, with a detail of the circumstances under which the bones of land animals are not unfrequently found in those rocks.

The varieties of this limestone formation have obtained, as is well known, different appellations from miners, among which zechstein is one of the principal. Near Politz, that kind of zechstein appears more particularly to prevail, which passes into the cavernous limestone, being traversed, as may be seen in the upper quarries, immediately under the new red sandstone, by very considerable fissures and cavities, which often exceed 12 feet in breadth, the walls of which are coated with stalactite; while the smaller fissures are frequently wholly filled with that substance. The rock ranges 30° to 45° to the E of S, and W of N, with an inclination toward the NE, in strata which are in some places a few feet thick, and in others very thin, alternating with slight layers of clay marl, that are partially sandy; being also traversed by numerous fissures in various directions. At the foot of the heights, this limestone approaches more nearly to the character of zechstein; and in the next quarry, near Politz, it contains aphrite, distributed in nests, yet only in small portions, and not in such considerable masses as occur on the other side of the Elster toward Gera. In the vicinity of the latter town, the rock appears as gryphite limestone, yielding, as is well known, fine specimens of gryphites aculeatus and g. cymbium, beside indistinct remains of other shells, which seem to belong to mytulites ceratophagus and terebratulites lacunosus. On the

* I have throughout this paper employed the expression *alluvial tracts or formations* (*aufgeschwememte gebirge*) in the sense established by common usage; namely, as a general term, comprehending both *diluvian* and *post-diluvian* deposits, yet involving no absolute decision with respect to either era. Wherever such epochs are distinctly marked, the latter terms become strictly appropriate; but in questions of a doubtful nature (such as that which constitutes the subject of the present article) the former retains its use. To confine the signification of the word *alluvial* to that of *post-diluvian* merely, as lately proposed, would be to deprive ourselves of a useful general expression. —T. W.

other hand, in the Politz limestone, I have not observed petrifactions of shells. At the latter place, the upper qua situated near the middle of the declivity, is particularly instr tive, exhibiting wide fissures and cavities, entirely filled with alluvial loamy deposit, that covers the whole country to a gr extent. Considerable masses of stalactite appear in sev places, and here principally were found those bones of la land animals noticed in the following description, and now c tained in my collection. They were met with at the depth about 20 feet, imbedded in the loam of one of the widest ca ties. They consist of

1. Lower bones of the foot, hollow bones, dorsal vertebræ, single fragments of bones, of the *rhinoceros antiquus* of Blum bach.

2. Lower jaws and single teeth of a species of *horse* of former world, particularly distinguished by the extraordin length of the teeth.

3. Dorsal vertebræ and hollow bones of ruminating anim belonging to species of the *ox* and *deer* tribes of the anci world, of an unusually large size. Of the latter occur also v large pieces of the horns, with the coronets adhering, and br antlers and branches of great length: these closely resemble drawings of Cuvier, tom. iv. pl. 1, fig. 3; but it is doubtful wh ther they are derived from the *Cervus elaphas primordialis*, from the *Alce gigantea*, the upper or palm part of the horns be wanting.

4. Lower jaws, with the teeth mostly in a perfect state preservation, of a large species of *hyæna* of the former wor *canis crocutæformis major*. Cuvier, tom. iv. p. 28, figs. 10, and 14.

5. Fragments of the upper and lower jaws, and single tusks the *leo diluvianus*, which approaches most nearly to the *jagu* Cuvier, tom. iv. pl. 1, figs. 3, 7. Compare with Mem. sur grands Chats, pl. 1, figs. 3, 5. It is doubtful whether the fra ments of one of these jaws do not belong rather to a ki of *tiger* of the former world.

All these bones are more or less changed and penetrated w calcareous matter, the alteration being particularly observable the bones of the rhinoceros, and in those of the ruminating a mals. The condition of the greater part of the bones of t other animals is nearly the same as that of the bones found the caverns at Gaylenreuth, Scharzfeld, and elsewhere; a hence it seems probable that they are of an equal age, and ref able to the same epoch of the ancient world. As, however, t fossil bones of the rhinoceros, and of the ox and deer tribes, principally met with in loam, calcareous tufa, and other alluv beds; and the latter in particular have hardly occurred in t chambers of the cavernous limestone (*höhlenkalkstein*) in co pany with those of bears, hyænas, lions, &c. it is certainly pos

bles that the remains of the land animals thus found commingled in the fissures of the limestone, compacted in the same alluvial soil that covers its surface, may be derived from different periods.* But as, on the one hand, the remains of several of the animals mentioned above have been found accompanying each other in tufaceous and loamy beds, e. g. near Kannstadt, Osterode, Thiede, and other places, it is also possible that they may be of a contemporaneous origin.†

Turning now our attention to the NW side of the Elster, to the heights above Kaschwitz, we find the gypsum there imbedded in the limestone, and appearing in the declivities. The former seems to have been laid bare by the destruction of the superincumbent limestone; but the latter becomes again visible in the slopes and eminences, proceeding toward Rubitz and Gera, occurring there in the form of zechstein and gryphite limestone.

The gypsum seems to constitute in this quarter a large isolated mass, included in the limestone. As far as exposed in the quarries, which have no where penetrated deeper than 30 or 40 feet from the surface, it is compact, and of so firm a consistency as to require to be blasted with gunpowder. Colour, greyish-white, rarely inclining to yellowish and flesh-red. It is sometimes striped in the ribbon and undulated manner, and alternates with slight layers of clay, in the vicinity of which it passes into the foliated variety, and acquires partially a greyish-black colour. Farinaceous gypsum occurs adjacent to the fissures, and also in their interior, in the form of nests. Specular gypsum has been met with only in crystals in the smaller crevices. Other varieties would probably be found, in the same manner as in Mansfeld, were the quarries conducted to a greater depth. No traces of salt springs have been discovered in the vicinity of the gypsum, though from the geological position of the latter such might have been expected.

The entire gypseous mass is intersected and perforated by fissures and cavities, which follow every direction, and are connected with each other by serpentine channels, of larger or smaller dimensions. But these fissures no where attain so great a breadth as those of the superincumbent limestone near Politz. They are, however, filled throughout in a similar manner with the same alluvial loamy deposit, even to the greatest depth; and this loamy sediment appears horizontally disposed for short dist-

* This argument seems to be invalidated by the consideration, that such remains have occurred together in other caverns, e. g. in England. (See Prof. Buckland's excellent paper referred to above, and also the Quarterly Review, Oct. 1822.)—T. W.

† According to the view of several naturalists, the bones of the animals met with in the caverns of Gaylenreuth, Liebenstein, Scharsfeld, &c. and the remains of bones found in the alluvial formations, belong to very different periods of the ancient world. This opinion, however, requires the stricter examination, since it is stated that the bones of elephants have occurred in some of those caverns; and in particular a large part of the skull of an elephant was thus met with in one of the caverns of the Hartz, which is now preserved in the collection of Blumenbach.

ances, yielding in clusters, as it were, and under precisely same circumstances, a number of bones of land animals, am which are distinctly to be observed also *human bones.*

Even from the first opening of these quarries, which t place about 30 years ago, the bones of man and other anin have thus been met with. According to the unanimous relat of the workmen, the former have usually been found at a de of 16 to 30 feet from the surface, and this has happenec almost every quarry that has hitherto been opened in the g sum, and always under the same relations. The cases are i in which human and other animal bones have appeared sin near the surface of the gypsum, adjacent to the vegetable s these have undergone a much greater change, are more pe trated with calcareous matter, and are heavier than the bo met with in depth. Our own experience confirmed the affir tion of the workmen, that various bones are always found to ther, assembled in a heap, as it were, in the loamy deposit. visiting Kornman's gypsum quarry, we discovered there ir nearly vertical fissure, and at the depth of 16 to 18 feet from surface, a number of bones belonging to quadrupeds and bir firmly imbedded in the loam. Though in a disjointed st they appear referable to skeletons, that were formerly more less complete. The idea has been advanced, that the bones the smaller animals might have been brought there by ov foxes, and other animals of prey; being, however, not found caverns, but invariably enveloped in the loam, under the sa circumstances, this supposition seems invalid; and it is besic contradicted by the appearance of the bones.

It is also evident that the human bones could neither ha been buried here, nor have fallen into the fissures of the gyps during battles in ancient times, nor have been thus mutilated a lodged by any other accidental cause in more modern day inasmuch as they are always found with the other anir remains under the same relations, not constituting connec skeletons, but collected in various small groups in the deposit loam, that occupies the fissures and cavities of the gypsu They appear, therefore, to be strictly *fossil, and to have b swept hither by floods, with the other animal bones, at the per of the formation of the alluvial tract itself.*

If, as may be expected, this phenomenon should be furtl confirmed by the more extended examination of the Köst district, now in progress, it will render probable the suppositi that the human bones found in calcareous tufa also, are likew referable to the same period; and consequently that *man exis here previous to the formation of the alluvial tracts, the last gr revolution to which the earth has been subjected.* It has be already remarked by Cuvier (Recherches, &c. tom. i. p. 6 that this epoch of a great deluge, by which many animals w destroyed, whose remains are now found in alluvial tracts alo and not in any strata of an earlier era, nearly coincides with c

chronology. And the tradition of such a deluge, preserved among all nations, now appears further confirmed by the instructive documents lying before us.

The following are the remains of bones hitherto found in the gypsum quarries near Köstritz, almost all of which are in my possession.

1. *Of Man.*—A perfectly preserved forehead, extending to one-half of the orbits of the eyes. The upper maxillæ, with the teeth mostly well preserved. The left side of the pelvis of a man, the left humerus, the right and left ossa femoris. The right thigh bone is in a more altered state than any of the other bones; and hence it is much heavier, having been found, according to the statement of the workmen, near the outcrop of a fissure. Beside these, some other fragments of human bones are contained in collections at Gera, and in that of the Natural History Society at Altenburg. All these bones are of a rather large, yet not unusual size, and certainly not of a gigantic stature, as stated by loose report.

2. Bones of *ruminating animals*, of the same description as those found in the fissures and cavities of the limestone near Politz, among which the deer's horns appear in a similar manner deprived of their animal gluten, or calcined, as it were.

3. Bones derived from animals closely resembling the *sheep* and the *roe*, although not wholly coinciding with the bones of the recent species.

4. The lower right jaw, with several dorsal vertebræ and hollow bones, of an animal very nearly allied to the *squirrel* (sciurus vulgaris). On comparing this jaw with a skeleton of the common squirrel, it is found to differ in some respects: the molar teeth possess a different direction, being considerably more elevated in the anterior part, while the foremost of them are much smaller, differently formed, and turned more outwards; the incisors also are of a much larger size. The proportions of the hollow bones and dorsal vertebræ are likewise considerably greater; and hence it is highly probable that we here possess a different species of the ancient world.

5. The greater part of the skull, with fragments of the scapulæ and cervical vertebræ, of a kind of *mouse*, which seems referable to the mus terrestris. These bones perfectly correspond with the delineations given by Cuvier of those which occur so abundantly in the osseous breccias on the coast of Corsica, tom. iv. Breches Oss. pl. 2, fig. 7. The skull of the specimen before us is deeply penetrated with gypsum, and, in some places, studded with crystals of that substance.

6. A number of bones of small quadrupeds, among which are some very remarkable jaw bones and teeth, which, though presenting some resemblance to those of the *bat* (sorex vespertilio) and *mole* (talpa), are yet for the greater part essentially different. Some of these bones agree perfectly with those met with in the

beds of calcareous tufa near Meissen; and there, as well as h are also found single bones of large kinds of *frogs*. Other bo seem to belong to the *hare* and the *rabbit*, and deserve to accurately examined and compared.

7. Bones of the *gallinaceous* tribe of birds, and probably of *marsh fowl*. The occurrence of the former is very remarka and I am not aware that they have been met with bef Among these is a perfectly preserved tibia, with the spur ad ing, which is very long in proportion, and agrees very clo with the corresponding bone of the *common* or *domestic* (gallus communis or gallinaceus). It is well known that common cock is principally distinguished by such a spur; w the peacock, the partridge, as well as the tetrao canadensis francolinus orientalis, possess, for the greater part, much sho spurs, and frequently only obtuse, knobby excrescences in t stead. There can be no doubt, therefore, that this bone is re able to a bird closely resembling the domestic cock. The len and form of the spur also prove, that it belonged to a full gr bird, and yet the bony tube is one-third smaller, and m thinner, than that of the common cock; the head of the join the knee and its posterior continuation also exhibit a sli variation in form; and hence it may be presumed that the b differed in some respects from the recent species. Almost the bones of the birds have undergone great change, and besp a high antiquity, although they do not appear in so perfe calcined a state as the bones of the rhinoceros, and the horn the deer.

Similar fossil bones are occasionally turned up by the plou in some parts of the fields in the vicinity of Köstritz, lying p bably concealed almost every where in the alluvial loamy s Great caution, however, should be exercised not to confou common bones, brought casually upon the land in carryi manure, with real fossil bones exposed at the surface by t operations of agriculture.

In the preceding pages, I have endeavoured to describe faithfully as possible all the natural circumstances by which th remarkable remains of bones are distinguished; and thougl have expressed my opinion, that they were swept hither a deposited during the period of the formation of the alluvial trac still it may deserve further inquiry, whether this view be t most probable, or whether bones belonging to different perio have been here commingled by other natural causes.

*Continuation of the Description of the Fossil Bones and th Repositories in the Vicinity of Köstritz.**

The very remarkable circumstance of fossil bones of anima

* From the Nachträge zur Petrefactenkunde of the Baron von Schlotheim. Got 1822.

of the ancient world being found intermingled without order with those of recent species, and with human bones, in the loam which occupies the cavities of the lower floetz gypsum in the vicinity of Köstritz, demanded the most careful investigation. The offer, therefore, of the Privy Counsellor Rudolphi in Berlin, a naturalist of experience and high repute, to compare and determine with exactness the nature of these bones, was highly acceptable; and I feel deeply indebted to that gentleman for his valuable services on the occasion.* The true character of several of the bones was so distinct as to require no further comparison; but it became necessary to transmit the far greater number to Berlin. Of these the largest portion has been most accurately determined, a few only remaining of a doubtful nature. In the mean time, I have received several packages from Köstritz, among which are some specimens that may require a careful examination; and of these I shall not fail to give a fuller account on a future opportunity.

Of *man*, the following fragments of bones have hitherto been dug up:

1. The os frontis, extending to the orbits of the eyes.
2. The upper maxillæ, in two corresponding halves, in which, with the exception of the incisors, all the teeth are perfectly preserved, differing in no wise from the recent.
3. A fragment of the lower jaw, with the molar teeth.
4. The left humerus.
5. The right femur.
6. The upper half of the left femur.
7. The left side of the pelvis of a man.
8. A fragment of one of the true ribs.
9. Single fragments of thigh and arm bones.

All these pieces are contained in my collection, and betray a great antiquity, although they have not all undergone a change in an equal manner. Some of them have lost their animal gluten, and are even penetrated with gypsum (as is the case also with a considerable portion of the other animal bones), while others are only slightly calcined and decomposed. This varying condition of the bones is likewise observable in all the fossil bones of Köstritz.

Of the animal remains generally admitted to have belonged to inhabitants of the ancient world, the most numerous met with near Köstritz are those of the rhinoceros, although, upon the whole, they are of rare occurrence. Of the elephas primigenius, the mastodon, and other gigantic land animals, no remains have hitherto been found in that vicinity.

* The Court Counsellor Oken also had the goodness to favour me with several observations on these bones, which have been confirmed in part by those of Rudolphi Whether the supposition of the former gentleman, that the human bones found near Köstritz are the remains of the Gothic men, the ancient inhabitants of Germany, be well founded, must be left for the decision of future experience.

The bones of the *rhinoceros* in my collection, derived froı limestone and gypsum quarries near Köstritz, are the follov

1. The second or third molar tooth of the right upper jaw perfect state of preservation.

2. A molar tooth, in an injured state, and wholly calc probably belonging to a young rhinoceros.

3. Several cervical vertebræ of the same, nearly complete but slightly altered.

4. A large dorsal vertebra, damaged, and much calcined.

5. Two fragments of the scapula of the rhinoceros, also n calcined.

6. A large and nearly perfect fragment of the right femı the same, perfectly calcined. It was found on Dec. 12, 1 in Friedemann's gypsum quarry, lately opened near Köstritz, at the same time fragments of human bones were also met v

7. The lower end of the left femur, in the same state, found at the same time.

8. Two perfect phalanges of the rhinoceros, calcined ı similar manner, discovered in Winter's gypsum quarry at depth of 18 feet from the surface. These pieces are particul deserving of notice, as beneath them, at the depth of eight further, were found the human bones mentioned under No. ! that list.

9. Single fragments of thigh and hollow bones of the saı from Friedemann's and Winter's gypsum quarries.

10. Very large fragments of the tibia of the rhinoceros, v the apophysis perfectly preserved, completely deprived of anı gluten, from the limestone quarry near Politz, not far fı Köstritz.

11. A fragment, probably belonging to the fibula of the rhiı ceros.

It is very remarkable, as has been already observed, that th bones should have suffered such different degrées of chanį and in this respect, the tooth No. 1 is particularly distinguish retaining still in part the perfect enamel. It deserves the grea attention, as it is deeply worn by mastication, being obviouı the tooth of an old animal. It is probably owing to this circuı stance that it so nearly approaches in form the tooth of t recent rhinoceros. All the other bones coincide fully with t delineations of the fossil rhinoceros given by Cuvier.

The fossil bones of the *deer tribe*, found in the Köstritz quı ries, are also in the same manner highly calcined. With respe to some of them, it remains doubtful whether they belong recent species, or to animals of the ancient world. My collecti contains:

1. A large fragment of the left scapula of the elk, which obviously much greater than that of the recent elk, and hence may, perhaps, really belong to the alce gigantea. From Winter quarry.

2. Four large fragments of the lower halves of very thick deer's horns, partly with the coronets adhering, and several very long branches. They are not sufficiently perfect to ascertain with certainty whether they appertain to the elk, or to other species of deer.

3. Similar fragments, of a smaller size, which may be referable to recent species.

4. Fragments of hollow bones, apparently belonging to the deer tribe.

5. A metatarsal bone of the right foot of an animal of the deer kind, which seems most nearly to resemble that of the roe; but it may have belonged to one of the antelopes, which, however, is mere conjecture. From Kornmann's quarry.

The remains of the deer tribe enumerated above were found partly in the gypsum quarries in the vicinity of Köstritz, and partly in those of the limestone near Politz.

Of the *horse*, several large pieces of bones have occurred, which perfectly agree with those of the existing horse; and the fragment of a jaw, which contains six teeth, appears also referable to the recent species. On the other hand, single teeth are sometimes met with, which are of a much greater length, and more curved in their form, and there can scarcely be a doubt that they are derived from the horse of the ancient world.

In the same manner, the bones of the *ox tribe*, of which the number found is rather considerable, coincide fully with those of existing species; and although some of them are remarkably thick, this distinction is not sufficient to claim for them an origin in the ancient world. It seemed, therefore, superfluous, as in the case of the bones of the horse, to describe them separately.

That the bones of the rhinoceros, of the deer, horse, and ox tribes, should be found in common in so many places, is a phenomenon that deserves particular attention. A similar occurrence has been again lately observed by Cuvier in the neighbourhood of Quercy.

Rudolphi has not ventured to decide upon the fibula of an unknown animal, found in Winter's gypsum quarry. By some, it was supposed to belong to the palæotherium of Cuvier, though, it would appear, on insufficient grounds. I have, however, in my possession, a tooth, which was met with in the beds of calcareous tufa near Meissen, that was considered by Rudolphi himself from the first as answering to that of the palæotherium; and this animal, thus occurring, as it seems, in alluvial tracts, it is at least possible that its remains may also be found in the cavities filled with loam, in the neighbourhood of Köstritz.

Of *beasts of prey* found near Köstritz, my collection contains:

1. Two considerable fragments of the right and left lower jaws of the hyæna, containing several molar and canine teeth, and the tusks. They perfectly correspond with the delineations of

Caries. The magnitude and strength of these remains p that they belonged to a larger species of the ancient world.

2. Two fragments of the lower jaws of a large animal belo ing to the cat family, with remains of the tusks and canine te probably referable to the jaguar of the former world.

3. Single tusks of the same animal.

4. A tusk which seems to belong to the bear found in caver

All these bones were discovered in the quarries of the super cumbent limestone near Politz, excepting some of the tu which were met with in those of the gypsum.

I now proceed to notice the bony remains of the *smaller li animals*, which evidently belong to well-known species of existing creation. There are a few, however, respecting wh some doubts remain, and which I shall particularly notice, requiring a strict examination.

1. Cervical vertebræ of the fox (can. vulp.)

2. The right lower jaw of a young dog, much calcined. T form and position of the teeth, however, which approach those of the marten (mustela martes), excite some doubts.

3. The os occipitis, and dorsal and cervical vertebræ, of t weasel (mustela vulgaris). They deserve the greater attentio as similar remains are found also in the beds of calcareous tu near Meissen.

4. A fragment of the right lower jaw of the shrew-mou (sorex araneus).

5. Five pieces of the lower jaws of very young moles, in very calcined state. The form of the jaw, however, differs co siderably from that of the recent species, possessing at the ant rior extremity a prominent hook-like process. Hence Rudolp is of opinion that they require further investigation.

6. The os sacrum of the hare (lepus timid).

7. A skull nearly complete, and single upper and lower jaw of the hamster (mus cricetus).

8. A lower jaw of the squirrel (sciurus vulg.)

9. A lower jaw of a similar animal, but somewhat differen which demands further examination.

10. A lower jaw of the field mouse (mus terrestris).

11. Several lower jaws of the rat (mus rattus).

12. Femora, tibiæ, and phalanges, of the common domest fowl.

13. Bones of the first toe and middle toe of the owl (stri bubo).

14. A fragment of the os femoris of another species of owl.

15. Several bones of frogs, some of which are of a larg size.

The bones of these smaller animals also betray for the greate part a high antiquity, although, like the other bones, the degree of change which they have undergone vary very much.

From the whole of the facts now detailed in the present and my former communication, it is quite evident that, in the country near Köstritz, human bones are found intermingled without order with the bones of animals of the ancient world, and with those of existing species, and under precisely the same circumstances, being firmly enveloped and compacted in the loamy deposit which occupies the fissures and cavities of the bed of gypsum that occurs in that vicinity.

It is undeniable that, in Winter's gypsum quarry, human bones were discovered at the depth of 26 feet from the surface, lying eight fee below the bones of the rhinoceros there also deposited.

The human bones, like those of the other animals, are more or less altered, and deprived of their animal gluten. Human bones and skeletons have also been found in other places, within the tract of the alluvial formations, in the vicinity of the repositories of large land animals of the ancient world; but which have not hitherto received that attention which they deserve.

All these considerations give, on the first view, probability to the conclusion, that the other animals were destroyed at the same time with man, and consequently that the latter was already in existence in this country at the period of the destruction of the large land animals; an opinion which I have already advanced.

Several important doubts, however, arise, when we closely examine into the local peculiarities and geological relations of other tracts, in which animals of the ancient world are usually met with; and when we also consider that such animals are found in common with recent species in the neighbourhood of Köstritz.

As far as hitherto known, such remains of recent species have not been found in any other place intermingled with those of the more ancient,* and still less with the bones of man. No remains of the large land animals of the ancient world have been met with in the osseous breccia of the coasts of the Mediterranean, which contains, according to the exact determination of Cuvier, only bones of recent species.

All the circumstances under which fossil human remains had hitherto been discovered in the latest deposits, obviously bespoke their modern destruction, and in the greater number of the recorded instances, implements and utensils were found in their vicinity, e. g. in Guadaloupe, near Pabstdorf, Burgtonna, &c.; and in the case of the first place, it is nearly proved, that a burying ground of the Caribs exists there, which is now washed by the sea, and covered with its deposits. All other reported cases of the occurrence of human remains in more ancient

* To this position, the Kirkdale cave in Yorkshire, in which, extinct and existing species occur together, appears to afford a direct answer. (See Prof. Buckland's luminous view of this question, in the paper already adverted to.)—T. W.

strata, or in caverns, accompanying the bones of beasts of p
have not been confirmed on a closer investigation; and, acc
ing to later inquiries, it appears even probable that the bo
and skulls of men found in beds of calcareous tufa, have b
lodged there in an accidental manner.

It is also to be remarked, that the remains of the large l
animals are always found in very low positions, in plains, on
banks of rivers, or in deep valleys, dells, and the concavitie
hilly ranges, deposited in the alluvial strata, which is also
case in the Köstritz district; and it is obvious that they w
here destroyed, and partly swept into such positions, by
concurrence of great floods. It is, moreover, highly proba
that in these operations land floods were the agent, and not
sea. But then the attendant phenomena ought to be unifor
the same. If the remains of man, now found commingled w
those of animals of the ancient world and of the existing cr
tion, were destroyed with them at the same time, we ought
find human bones distributed in all parts of the alluvial tract
But this phenomenon has as yet appeared only in the loa
deposit in the Köstritz gypsum, confined to a narrow space, a
under peculiar circumstances.

The principal of these circumstances are the following: T
narrow valley which extends from Kaschwitz toward Köst
is bounded on the eastern side, near Politz, by a much m
considerable range of eminences than on the other side, whi
though gradually becoming more elevated toward Jena, is p
tially interrupted by dells and circular concavities. The de
narrow valleys and defiles prevailing in the neighbourhood
Jena, in the valley of the Mühl, and further toward Drackend
and Köstritz, clearly show the power with which the anci
waters raged, when those channels were excavated in which
present flow the Saale, the Elster, and the adjoining smal
streams. It is manifest that during the course of this operati
large tracts of the limestone superincumbent on the gypsum,
well as of the new red sandstone, were torn and swept aw
and that the gypsum, thus laid bare, was repeatedly cover
and its cavities filled, with the sediment of the waters, the exi
ing loamy soil.

That the bones of the same species of animals, as well
human bones, should be found without order at differ
depths, and even immediately under the vegetable soil, lyi
upon the superior strata of the gypsum, is a circumstance ten
ing rather to confirm than refute the idea of repeated depositio
In the same manner, to find animals belonging to very differ
epochs, assembled only in the gypsum, where situated in t

* This argument proceeds on the assumption that the human race had overspread
whole face of the earth, at the period of the formation of the alluvial tracts. The p
ical evidence, however, hitherto obtained from the investigation of those tracts, se
to indicate the contrary.—T. W.

lowest position, seems to indicate floods in more recent times; more especially, as no animals of the existing creation have been found in the cavities of the superincumbent limestone,* placed on a higher level. These cavities, which are filled with the same loamy soil, seem to have been the repositories of the bones of beasts of prey, in the same manner as the caverns of Scharzfeld, Liebenstein, &c. and these bones appear to have been swept away by later floods, and deposited singly in the cavities of the gypsum, situated upon a lower level, and which presents in this spot the form of a basin, being one of the lowest positions in the district. Hence it is highly probable that animals of the ancient world, belonging to very different repositories and very different eras, reaching in part even to the remotest antiquity, have been here repeatedly brought together, and commingled in later periods with the remains of recent animals, and the bones of man; yet in a manner very different from those met with in strata of calcareous tufa.† This substance, considered as the gradual and tranquil production of great lakes, covering on the spot the skeletons of large land animals previously swept thither and deposited, appears, for the most part, to belong to the more ancient of the alluvial formations; and this high antiquity is also evinced by the state of the bones found in the tufa, which are perfectly calcined, and also partly petrified. Upon the breaking down of the dams which confined the lakes, and the outflow of their waters, a part of the land animals buried within their bosom appears to have been carried to a greater distance; and to this cause, and more stormy floods, we may in part attribute certain depositions of loamy soil, in which are sometimes found considerable beds of boulders and pebbles, composed of limestone and other substances. In the district of Köstritz, even boulders of granite, of a considerable size, and which are foreign to the country, are found in the loamy deposition, which occupies the fissures and cavities of the gypsum.

The great difference in the state of calcination exhibited by the Köstritz bones, will long remain enigmatical, as well as several other of the peculiar circumstances that have been adduced; and I am far from thinking satisfactory the attempt which I have made to explain the phenomena. At present, I consider it as most probable, that the human bones thus found belong to a much later epoch than the large land animals of the

* This assertion of the author is surprising, after having stated above that the bones of the ox tribe, found in the cavities both of the limestone and gypsum, are all referable to recent species; while the remains of the horse met with only in the limestone, coincide, it is said, for the most part, with those of the existing species.—T. W.

† The occurrence of bones of the common domestic fowl seems, in particular, to bespeak a much later epoch; unless we assume (notwithstanding the local peculiarities attending them are contrary to the idea), that they were carried thither by beasts of prey, and that the place of their deposit has been subsequently filled, perhaps even in the latest period, with loam, the bones thus becoming enveloped and cemented in its mass.

ancient world. So much, however, appears to be proved, they occur here in a really fossil state, having been bro thither by great floods at very remote periods.

Note by T. W.—In considering all the natural circumsta detailed by Baron von Schlotheim, following the course of argument, and comparing both with the instructive facts views contained in Prof. Buckland's paper (which may be val as a model of just induction), the question arises, whether phenomena attending the animal remains found in the dist of Köstritz may not be most consistently explained by ascril them to the effects of diluvian action? The existing form of surface, the general distribution of the same sandy loamy over that surface, extending many miles in every direction, the deposition of precisely the same soil in the fissures cavities both of the limestone and gypsum, containing, it wo appear, boulders and pebbles of limestone and other substan and even of granite, a rock not to be found *in situ*, but at distance of many miles: all these relations seem to besp the operation of one great cause at one fixed period. Nov the animal remains met with near Köstritz, it is to be observ

1. That those which are merely confined to the fissures cavities of the *limestone* are referable to the horse, belong partly to an extinct species, but mostly agreeing with the ex ing horse.

2. The remains found in the cavities and fissures both of *limestone* and *gypsum*, relate to

The rhinoceros, an extinct species.

The deer tribe, extinct, and apparently also existing, speci

The ox tribe, recent species.

The hyæna, and an animal approaching to the jaguar, b extinct species.

3. While the remains confined to the cavities and fissures the *gypsum* consist of

The bones of man, of the fox, dog or marten, weasel, shr mouse, field-mouse, rat, hamster, squirrel, hare, mole, dome fowl, owls, and frogs; which agree with existing species, w some exceptions, however, which appear to require further vestigation.

It may be asked, if the whole of these remains were deposi at the same era, whence does it proceed that they are not distributed in the fissures and cavities of the superincumb limestone, as well as in those of the subjacent gypsum? To t the natural answer seems to be, that, the limestone occupyin more elevated position, the greater mass of animal rem would follow the deeper current of the diluvian waters, become princi..."

current. Now this is precisely the position of the gypsum, in which those remains are found. If it be maintained that the animal remains deposited in the cavities and fissures of the limestone and gypsum, belong respectively to different epochs; and that of such as occur in both; namely, the rhinoceros, ox and deer tribes, hyæna and jaguar, these were at later periods washed out of the limestone, and then deposited with the other remains in the gypsum, it may be inquired, why were not the remains of the horse equally dislodged? And as the fissures and cavities of the limestone are described to be entirely filled at present with the same loamy deposit as those of the gypsum, it may also be asked, in what manner could the former be partly emptied, and yet be filled again with the same alluvium at those supposed different epochs? And how could the cavities of the gypsum have remained empty, while those of the limestone were filled during the first of those periods. There appears to be an inconsequence in such a supposition. If, again, it be contended that the whole of these deposits were post-diluvian, it may be remarked that this seems to be contradicted by the same loamy soil which occupies the fissures and cavities of the limestone and gypsum, being spread over the whole country to a great extent. It is true, Baron von Schlotheim appears to suppose the former existence of a lake, whence the waters flowing out, on the breaking down of its barriers, bones belonging to different repositories and different eras have been commingled and swept together. But lakes, in the natural course of things, have a tendency to filling up, by a gradual accumulation on their bottoms, and not to bursting their barriers. Of the former existence of many such inland seas and lakes, there is ample evidence in the present form of the surface of the earth; but the gorges and defiles, by which their waters were discharged, clearly show that those channels were excavated by a mighty power; and as no physical cause now in action could have produced such effects, it may fairly be inferred that it was not post-diluvian. Where then is such a power to be found but in the agency of the diluvian waters, or in the more ancient causes which operated during or subsequent to the deposition of the earlier strata?

It is also to be observed, that in the fissures and cavities of both formations, the remains met with belong partly to extinct animals, and partly to such as agree with existing species. In considering the animal remains discovered in caves and in diluvian tracts, it appears hitherto to have been the practice to confine the terms "animals of the former, ancient, or antediluvian world to such as are now extinct. If the deluge was the great agent by which land animals were destroyed; and if in the existing order of beings the races were renewed with certain exceptions, we might expect to find in the depositions consequent to that catastrophe, the remains both of extinct animals, and of such as correspond with recent species; and we do so find them, e. g. in the cave, or rather series of caves, lately dis-

covered at Oreston, near Plymouth; and that these are refer to antediluvian races, appears to be proved by the unequiv circumstances attending analogous remains in the Kirkdale in Yorkshire. If this be admitted, it will require the stri caution in distinguishing between diluvian and post-dilu deposits. The satisfactory solution of the general problem far as it relates to man, is probably to be sought more part larly in Asiatic regions, the cradle of the human race. Whe fossil remains of the recent elephant, rhinoceros, hippopota and hyæna, are to be found in the diluvium of tropical clima becomes also an interesting branch of the inquiry, since it been conceived that the fossil species of those races distrib throughout the greater part of the temperate and frigid zone the northern hemisphere, being different, were by nature ada to those regions, and perished where they lived. In the m time, in a district so highly interesting as the neighbourhoo Köstritz, it cannot be too strongly recommended to natura to continue to explore, and scrutinize with all that preci which the subject obviously demands, all the natural circ stances under which the various deposits of animal remains to be found in the fissures and cavities both of the gypsum limestone, as well as in the general tract of sandy loamy diffused over the surface of that country. In investigating a question, a comparative view of the levels of the country relation to those deposits, would form an instructive part of inquiry.

Article III.

On the Temperature of Mines. By M. P. Moyle, Esq.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Helston, Dec.* 8, 18

The difference of opinion evinced by Mr. Fox and my relative to the augmented temperature of the earth in the des from its surface, seems to have drawn considerable attenti and as strong arguments are brought in support of decid opposite theories, I consider it but just that the public sh be in possession of all the facts, sentiments, and experime to ground theirs. It, therefore, will become necessary to m a few remarks on what has been advanced by Mr. Fox and Forbes, in the Transactions of the Cornwall Geological Soci as well as that published by the former in the *Annals of Pi sophy.*

Some few of my earliest experiments you have done me favour of publishing in the *Annals* for April and June These experiments, together with others, formed the subst

of my communication to the same Society, and which has been published in the second volume of their Transactions. The substance of this communication I conceive it necessary in this place to detail, as I shall have frequent occasion to refer to it. I have since collected some additional facts which, I conceive, will tend to strengthen very materially the opinion I originally advanced. These shall follow in the second place, reserving any comments for the conclusion.

As it is only by comparing the different results of the experiments of individuals that the truth, or an approximation to it, can be elicited, I conceive too much attention cannot be paid to the manner in which these experiments are conducted. With respect to the temperatures now given, where there has been any degree of uncertainty in the result, they have been taken twice or thrice in the same spot, by different methods, such as burying the thermometer in the earth, or rock of the gallery, in mud or water, lodging in the gallery, in the full stream of water flowing from the veins, by allowing it to remain 15 or 20 minutes during each observation, and by the correspondence of two or more thermometers at the same time.

I have lately ascertained the temperature of three levels which have been driven from Crenver directly under the deepest level in Trenoweth (the mine alluded to in the Annals for April, p. 416). At the depth of 124 fathoms below the adit level, or 936 feet from the surface, it was 57°; at 984 feet, 58°; at 1044 feet, 58°. Five months before, when the miners were at work in the last mentioned level, the temperature was 68°.

In Oatfield copper mine in May, 1822, the temperature of the air in the engine shaft at the adit level was 61°. At the depth of 1092 feet from the surface, it was 77°, and at 1272 feet, and 480 feet east of the shaft, 78°; at 1332 feet, and 600 feet east of the shaft, it was 81°; but at the same level, 360 feet west of the shafts, it was only 78°: neither of these spots were working places; but the latter was more contiguous to them than the other. At the depth of 1392 feet, in a working part 72 feet east of the shaft, it was 80°; and only 24 feet deeper, 180 feet west of the shaft, in a confined *end,* it was 85°. Here the water issuing in considerable streams from two small veins, at the bottom of the gallery, a few feet apart, indicated the different temperatures of 82° and 86½°.

Since the temperature of the different parts of this mine has been taken, the pumps have been drawn up from the deepest part, and the shaft, below the depth of 182 fathoms from the surface, has been for some months full of water. At this level, the temperature was previously 77°, but a few months afterwards (in Sept. last), when the water had risen to the level, its temperature, a few feet below its surface, was 69°; and at the depth of 72 feet in the water, it was 71°. A *fortnight* after this, I repeated the experiment, and found the temperature, a few feet

below the level, 66°; and at 12 fathoms, as before, deep in t water, 67°; it having cooled 3° in a fortnight, and 11° since admission into the shaft.

In Crenver copper mine, very little work has been done fo great while. At 300 feet, and 300 feet east of the engine sh the temperature was 55°; at 432 feet deep, 56°; at 492 fe 61°; at 617 feet, 62°; at 672 feet, 64°; at 732 feet, 64° in shaft; but in a gallery 360 feet east, only 60°; at 792 feet, in the shaft; but 1200 feet east of it, only 61°; at 852 feet, 6 but at 180 feet west, it was 64°; and at 1200 feet west, it v 68°.

Huel Abraham is on the same lode as Trenoweth, Crenv and Oatfield; and is, in almost every part, in full work. 1332 feet below the surface, the temperature was 84°. At 1 feet deep, at the extremity of the level, on a Monday morni before the workmen had returned to labour, and where a mach was erected for blowing fresh air to the miners, the thermome stood at 90°; but a few days afterwards, when a communicat had been formed, it fell to 86°. At the depth of 1452 feet was, in one gallery, 84°; and in another (the only spot wh there were no workmen), it was 86°.

I shall now mention the result of some experiments, to asc tain the temperature of the water, at different depths, in mi which have been long abandoned.

Herland copper mine, in Gwinear, has ceased working (exc above the adit), 15 years. On the 28th May, 1822, while temperature in the shade at the surface was 64°, and in the 74°, I found that of the water running through the adit, fathoms deep, 52°; as we approached the engine shaft, it increased to 53°; and on sinking two self-registering ther meters, properly secured in a box with iron weights, the temp ature, at the depth of 10, 20, 40, 60, and 100 fathoms in water, and 792 feet from the surface, was uniformly 54°. another shaft in this mine, 360 feet north-west of the gr engine shaft, the water running through the adit was 54°; at 10, 20, and 40 fathoms deep, 56°.

On the 8th of June, 1822, I visited Huel Poel and Huel R lead mines near Helston. In the former, the temperature of water, at 10 and at 20 fathoms deep, was 53°. In another sh it was precisely the same.

In Huel Rose, the water in the engine shaft was, at 60 deep, 53¼°; at 120 feet, 53¼°; at 240 feet, 53¼°; and at feet, only 53°. The time allowed for the thermometer to rem at the different depths (except the last) was 10 minutes, whi perhaps, was scarcely long enough.

In Huel Alfred (visited in July, 1822), the temperature of water in the adit, 18 fathoms below the surface, was 56°; an the several depths of 60, 120, 240, 360, 600, and 672 feet water, or 780 feet from the surface, it was uniformly the sam

Relistian mine in Gwinear (visited on the same day) is reported to have been, when at work, much hotter than mines in general; but I found the water in the adit, 25 fathoms deep, only 55°; and at 10, 20, and 25 fathoms below the adit, it was still the same.

Huel Ann an old tin mine, 353 feet above the level of the sea, is situated in granite, and is on the same lode as Huel Trumpet, in the parish of Wendron. This mine has not been wrought for the last 20 years, but is to be immediately reworked; and men have consequently been employed to open that part of the mine above the adit. On uncovering a shaft, I found that I could drop 120 fathoms perpendicular. This I did with half a hundred weight, to which was affixed a common bottle properly corked, sealed and secured, so that with a small cord affixed, the cork was withdrawn after a lapse of a few minutes. The water thus drawn from the bottom was of the temperature of 52°, and a pint of it left only a residuum of $1\frac{1}{4}$ gr. I then sunk a day and night thermometer properly secured, as in my former experiments, and found the temperature at the depth of 30, 60, 120, 240, and at 720 feet, or the bottom of the mine, uniformly of the temperature of 52°. The adit is 14 fathoms, thus making the depth from the surface 804 feet; and the thermometer was allowed to remain at the bottom of the water for four hours.

On repeating my experiments on the temperature of the water in the Herland mine, I found the heat at all depths, as before stated, viz. 54° in the old engine shaft, and 56° in another about 60 fathoms distant; and in a third, not before tried, the water was only 52°. I was given to understand by Capt. S. Grose, who accompanied me, that all these shafts extended to nearly the same depth. This circumstance I conceive rather remarkable, and clearly proves the operation of different causes of temperature in a very circumscribed portion of ground.

At Huel Franchise, a tin and copper lode in the parish of Wendron, 313 feet above the level of the sea, and parallel with Huel Trumpet. The water in this mine, which has ceased working for about two years, was in November last at the bottom, or 180 feet in depth, 51°.

Huel Nancy is on the same lode, but half a mile east of the latter mine. This mine is about 200 feet deep, and indicated at all depths 51°; while the temperature in the shade at the surface was 55°. This mine has stopped more than 20 years.

In making my experiments with the registering thermometer, in order to obtain as correct results as possible, I always reduce the degree of the mercurial one to about the freezing point, by sprinkling its bulk with ether, and by raising the spirit one with my tongue, bringing the indices to correspond before each immersion.

There appears to be little or no difference in the mean temper-

ature of the same spot in a *deep* and confined part of a mine work, in summer or winter; or at least the miners are not sen ble of any. Capt. W. Teague assures me, that he has often m with ice in great abundance in Tin-Croft mine, at the depth 318 feet below the surface; and in such quantities that the l ders have been impassable; deep crevices in the walls have be completely filled, and icicles hanging abundantly around him

As liquid and aeriform bodies convey heat on a different pr ciple from that observed in solids, viz. by an actual change in situation of their particles, instead of an augmentation of th bulk, as in solids, in proportion to the absorption of caloric may not be deemed irrelevant to explain this principle, and ap it to the circumstances of the water in a relinquished mine, a show how the whole water becomes of an uniform temperatur

Supposing the greatest temperature is at E, the bottom of the mine, and the whole becomes filled with water by infiltration from the surface. This water must bring with it a medium temperature of the surface, and the different strata of earth through which it has passed, which, if of less heat than that possessed by the earth at the bottom, will of course become heated to the same degree; it, therefore, is expanded, and, becoming specifically lighter, ascends to the surface, and is replaced by a colder portion from above. This, in its turn, becomes heated and dilated, and gives way to a second colder portion; and thus the process goes on as long as the fluid is capable of imbibing he Therefore, whether the thermometer is sunk to A, B, C, D, or in an old mine, it must be found of an equable degree.

M. de Mairan asserts, that the rigour of the cold of winter tempered by the heat imparted to the atmosphere by the ear itself, which heat, probably possessed from its origin, is pr served and renewed by the incessant influence of the sun, which one half of its surface is constantly exposed.

Admitting this fact, the temperature of the atmosphere mu depend on the capacity of the earth for receiving and retainin heat, and for communicating it to the surrounding mediu But as the earth is composed of land and water, it should b considered that the capacities of these constituent parts, f receiving heat are very different. Land, particularly whe dry, receives heat from the sun's rays very readily, bu transmits it through its own substance to great depths ver slowly; and, on the other hand, water, by reason of its transpa rency, receives heat very slowly, but diffuses what it receive more readily.

Dr. Hales found, that in the month of August, 1724, when th air and the surface of the earth were both at 88°, a thermomete placed only two inches below the surface of the earth stood a 85°; another, 16 inches under the surface, indicated 70°; and

third, 24 inches deep, stood at 68°. The last two thermometer preserved the same temperature, both day and night, till the en of the month, and then fell to 61°, the earth obstinately retainin its heat at that depth, though the temperature of the air fre quently varied. On the 26th of October, a thermometer expose to the air stood at 35·5°; but one sunk two inches below th surface was heated to 43·85°; another, at the depth of 1(inches, stood at 48·8°; and another, 24 inches deep, showe 50°; and from the 1st to the 12th of November, when the tem perature of the external air was 27°, a thermometer placed a the depth of 24 inches, stood at 43·8°; but from the month o March to that of September in the following year, the externa air was constantly warmer than the earth at the depth of 16 or 24 inches.

From these experiments, it may be inferred that the surface of the earth is much heated during summer, but that the heat descends very slowly, a great part of it being communicated to the air; that during the winter the earth gives out to the air the heat which it had received during the summer; and that wet summers are generally succeeded by cold winters.

Marriotte's experiments furnish nearly similar results to those of Dr. Hales. Hence it appears that at the distance of about 80 or 90 feet below the surface, provided that there be a communication with the external air, or at a less depth if there be no communication, the temperature of the earth admits of very little variation, and generally approaches to the mean annual heat.

M. Van Swinden has observed, that the greatest cold, and even that which is below 0° of Fahr. if it lasts no more than a few days, penetrates no deeper than 20 inches, when the earth is covered with snow, and not above 10 inches, if no snow lies on the surface.

Such facts tend to prove that the heat of the earth does not increase as we descend into it; but at the greatest depths, it is nearly the same as the mean annual temperature of the latitude.

The following table of temperatures, taken by myself, will be convenient for a general reference, distinguishing the mines at work from those long since abandoned; and the medium in which the temperatures were taken:

		Mines at Work.														Abandoned Mines.											
Depth from surface in feet.		Huel Unity.		Creegbraws.		Huel Trumpet.		Oatfield.		Cronver.		Huel Abraham.		Huel Treroweth.		Huel Pool.	Huel Rose.	Relistian.	Herland.			Huel Alfred.	Huel Ann.	Trevennen.		Huel Fanchise.	Huel Nancy.
		a.	w.	a.	w.	a.	w.	a.	w.	a.	w.	a.	w.	a.	w.				Shafts. 1.	2.	3.			a.	w.		
60 to	120	—	Not working spots.	—	51	—	56	—	—	All spots not at work.		—	—	—	—	53	53½	—	—	—	—	56	52	—	—	—	—
120	150	54		55	—	—	—	—	—			—	—	—	—	53	53½	55				56	52	53½	52	51	51
150	200	—		60	—	—	Not working spots.	61	—	—	—	—	—	54	—	—	—	55	54	56	52	56	—	—	—	51	51
200	250	—	—	—	—	—		—	—	—	—	—	—	54	53	—	53½	55	54	56	52	—	—	—	—	—	—
250	300	—	—	62	—	58	54	—	—	55	—	—	—	54	—	—	—	55	—	—	—	56	52	—	—	—	—
300	350	62	54	—	—	—	—	—	—	56	—	—	—	—	—	—	53	55	54	56	52	—	52	—	—	—	—
350	400	—	—	—	—	—	—	—	—	60	60	—	—	54	—	—	—	—	54	—	—	—	—	—	—	—	—
400	450	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
450	500	—	—	—	—	—	52	—	—	61	61	—	—	—	—	—	—	—	—	—	—	—	52	—	—	—	—
500	550	—	—	—	—	67	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	56	—	—	—	—	—
550	600	—	—	—	—	68	53	—	—	62	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
600	650	71	69	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	54	56	52	—	—	—	—	—	—
650	700	—	—	—	—	—	—	—	—	64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700	750	—	—	—	—	—	—	—	—	64	60	—	—	—	—	—	—	—	—	—	—	56	52	—	—	—	—
750	800	—	—	—	—	—	—	—	—	63	{a 61 {w. 61	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
800	850	—	—	—	—	—	—	—	—	64	62	—	—	Level from Cronver.		—	—	—	—	—	—	—	—	—	—	—	—
850	900	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
900	950	74	65	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
950	1000	—	—	—	—	—	—	—	—	—	—	—	—	53	—	—	—	—	—	—	—	—	—	—	—	—	—
1000	1150	—	—	—	—	—	—	—	—	—	—	—	—	58	—	—	—	—	54	—	—	—	—	—	—	—	—
1150	1250	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1250	1300	—	—	—	—	—	—	78	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1300	1350	—	—	—	—	—	—	81	78	—	—	85	84	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Secondly, it is necessary to make a few remarks on what Mr. Fox and Dr. Forbes have stated, trusting that those gentlemen will excuse the liberty which I have taken.

In Mr. Fox's tables, the irregular ratio of augmented temperature is very conspicuous; as it appears to be as hot at the depth of 600 feet in Chacewater mine, as it was in Dolcoath at the depth of 1440 feet, each being 82°. In the next place, it is as hot at 420 feet in the United Mines, as in Dolcoath at 1200 feet; as hot in Chacewater at 480 as at 840 feet in Huel Damsel; as hot at 780 feet in Treskerby as at 1380 in Dolcoath, &c. &c.; and hotter in the United Mines at the depth of 1080 feet than in any other mine in the county. From this statement, it appears that the temperature of the earth in Chacewater increases 27° in 540 feet in depth; while Dolcoath is augmented only the same in 1380 feet; and the United Mines the same number of degrees in 1080 feet, or exactly double the depth. These facts would induce me to look upon the progressive ratio of heat in a different light from those gentlemen.

Mr. Fox and Dr. Forbes are at variance in opinion about fixing a limit as to the precise point below the surface, for the commencement of augmented temperature: an examination of an experiment or two will prove the confidence we may place in the conclusions of either.

Mr. Fox commences at 50 feet, and Dr. Forbes at 200 feet, below the surface; and from the extreme temperature observed in our deepest mines, would deduct 6° for artificial and extraneous causes of heat, thus reducing the actual degree at about 1300 or 1400 feet from 72° to 74°; and after the ratio of 1° for every 50 feet, it would be at the depth of 1044 feet, 68°. Now reverse the order of calculation, and we shall find Mr. Fox to make it $69\frac{1}{4}$°, and Dr. Forbes, $66\frac{1}{4}$° for the same depth. This is the precise depth of the lowest of the three levels driven under Trenoweth from Crenver, the temperature of which is actually only 58°, although a spot not in the course of working, yet has a distant communication with the mine in general, and at a working spot on the same level, the temperature is but 68°, after being exposed to all the extraneous sources in common.

Dr. Forbes remarks (and Mr. Fox in his last communication says the same), "hence it follows, that the *natural temperature* of the earth in the mines in Cornwall, at the depths mentioned, must be considerably above that of the mean of the climate. This conclusion is equally deducible from many facts which have been observed in mines. The most conclusive of these is the high temperature of extensive collections of water in abandoned mines, or in parts of mines that have been long since abandoned. In cases of this kind, it is impossible to believe that the temperature can have been derived from any other source than the rocky walls of the cavity in which it is contained; and as these walls could not derive their temperature

from any foreign source, the conclusion is equally in favour the natural high temperature of the body of this earth at cert depth."

Will these gentlemen, I would ask, still maintain the sa sentiments? If so, their theory must fall to the ground, as can now clearly prove that these very collections of water posse even a less temperature than the supposed mean of the climat e. g. Huel Ann, and the third shaft in Herland; one 130, and t other 160 fathoms in depth, Ding Dong, Huel Rose, Huel Fra chise, &c.

The only instances of importance, Dr. F. brings in support this hypothesis, are the following: a large isolated collection water in Botallack mine is stated to be 62° at the depth of abo 400 feet from the surface. Here it may be necessary to refer his general description, and we find it is an old working full water, 80 fathoms deep below the gallery at 400 feet, and under the sea. The surface of this water is 62°, while the a was 66°; the heat of *this water at the bottom of the working not given.* He continues, "a still stronger instance, perhaps, i support of the same conclusion, is afforded by the details o the other submarine mine Little Bonnds. This mine wa formerly worked to the depth of 500 feet. Of late years, ver little has been done, and the water has risen to within 4(fathoms of the adit, where it is kept stationary by the partia operation of the pumps. There is thus a permanent body o water extending from the depth of 300 to that of 500 feet below the surface, and, perhaps, to half that distance horizontally. This water, as discharged by the pumps in 1822, is of the temperature of $56\frac{1}{4}$°." Pray what has this to do with the temperature of the central part or bottom of the collection? And yet Dr. F. in nearly the following page, states, that a large body of water resembling the last has accumulated in the old wrought part of Ding Dong mine; at the depth of 444 feet below the surface, the workmen had just cut through the barrier which divided them from this old working, and the stream of water which issued forth (and which was the bottom of the large collection), was only $52\frac{1}{2}$°, thus at once proving what is actually the case, that, as I before stated, it may be as cold at the very centre of the earth as at any distance beneath its surface.

In the next place, I do not conceive that their opinion can be supported, because Dr. Forbes's philosophical reasoning on all the extraneous sources of caloric falls short of what is actually observed, and that we must attribute this extra portion as derived from the earth itself; for I should imagine that there are few more difficult problems, than a true estimation of the power of the *infinite* sources of caloric in a mine in the full course of working.

In making a few observations on the foregoing experiments, I must remark in the first place, that in mines which are at work

scarcely two places of equal depth below the surface, and under similar circumstances, exhibit the same temperature. As these differences and irregularities of temperature always occur in mines which are at work, they must arise from adventitious causes. I am, therefore, of opinion, that the true temperature of any part of a mine in the full course of working is difficult of attainment, and that we must have recourse to those mines, and parts of mines, which have been long since quitted by the miner, in order to obtain any thing like a true datum.

The hot springs which frequently occur, while they prove the existence of causes sufficient to give them their high degree of temperature, prove, at the same time, by their rarity, the local and adventitious nature of those causes.

I cannot conclude without stating, that I hope those gentlemen who have taken such an interest in the present inquiry, will not lose sight of it, but avail themselves of every opportunity likely to develope this apparently mysterious subject; and as we are in possession of the temperatures of Huel Ann, and the Herland mine, and which are to be immediately reworked, and of Huel Abraham, our deepest mine, which report says is about to be relinquished, I think a favourable opportunity will occur to reverse the nature of our present experiments, and thus afford by synthesis, as well as analysis, an accurate statement of facts. I am, Sir, your obedient servant,

M. P. Moyle.

Article IV.

On the State of Water and Aëriform Matter in Cavities found in certain Crystals. By Sir Humphry Davy, Bart. PRS.*

There are few inquiries in natural science more calculated to awaken our curiosity, than those relating to the changes which the matter composing the surface of our globe has undergone. The imagination is excited by the magnitude of the operations by the obscurity of the phenomena, and the remoteness of the time at which they occurred; and all the intellectual powers are required to be brought into activity to find facts or analogies, or to institute experiments, by which they may be referred to known causes.

The crystallizations constituting the whole of the rocks which are usually called primary, and those found in such abundance, even in the rocks which are termed secondary, prove that a considerable part of the materials of the surface of the globe

* From the Philosophical Transactions for 1822. Part II.

must have been either fluid or aeriform; for these are the states from which the regular arrangements of the molecul bodies constituting crystals, can be produced.

Geologists are generally agreed that the greater number o crystalline mineral substances must have been previously liquid state; but different schools have supposed diff causes for their solution; some attributing this effect princi to the agency of water, others to that of heat.

When, however, it is considered, that the solvent pow water depends upon its temperature, and its deposition of matters upon its change of state or of temperature; and being a gravitating substance, the same quantity must al belong to the globe, it becomes difficult to allow much weig the arguments of the Wernerians or Neptunists, who have g rally neglected, in their speculations, the laws of chem attraction.

There are many circumstances, on the contrary, favourabl that part of the views of the Huttonians or Plutonists, relatin the cause of crystallization; such as the form of the earth, of an oblate spheroid flattened at the poles; the facility which heat, being a radiating substance, may be lost and d pated in free space; and the observations which seem to s the present existence of a high temperature in the interior o globe.

I have often, in the course of my chemical researches, loo for facts or experiments, which might throw some light on interesting subject, but without success, till about three y ago; when, in considering the state of the fluid and aerif matters included in certain crystals, it appeared to me, these curious phenomena might be examined in a manne afford some important arguments as to the causes of the for tion of the crystal.

It is well known that water, and all fluids at usual temp tures, are more expansible by heat than siliceous or other ea matters; and supposing these crystals to have been formed, the water or fluid enclosed in them, at a pressure and temp ture not very unlike those of our existing atmosphere, this f ought to fill nearly the same space as when included, and elastic fluid confined with it, supposing it non-absorbable, ou to be in the same state of density. On the contrary, if earthy matter and the fluid separated from each other und much higher temperature than that now belonging to the face, a certain vacuum might be expected in the cavity from contraction of the fluid, and if any gas were present, a consi able rarefaction of it; and though, supposing a much hig temperature on the surface of the globe, the atmosphere forn by aqueous vapour must have had much greater absolute weig which, as liquids are *compressible*, must have influenced volume of the fluid at the time it was enclosed, a circumsta

which would render it impossible to draw any conclusion as to the exact temperature, yet still the experiments appeared to offer, on any view, interesting results; and I was the more desirous of performing them, as I believe the nature of the fluid and aeriform matters included in rock crystals and other siliceous stones, has never been accurately ascertained.

Having purchased some crystals, and having had others committed to my care by the liberality of my Brother Trustees of the British Museum, and of my friend Prof. Buckland, I proceeded to make the necessary experiments upon them. It will be improper for me to take up the time of the Society by a minute description of my manipulations. Holes were drilled in the crystals by the use of diamonds, generally by Mr. Newman, under distilled water, or mercury, the gas was expelled by the introduction of wires, and the fluids included in the cavities were drawn out by means of fine capillary tubes, and experiments were afterwards made to determine the space they occupied, which had been accurately measured and marked upon the crystal. The chemical nature of the fluid and gas was determined by processes which were necessarily difficult from the smallness of the quantities operated upon; but which are too well known to the chemical philosophers of this Society to need description.

The first three crystals that I examined were from Schemnitz, in Hungary; the cavities that they contained were proved not to be permeable to the atmosphere, by exposure to rarefied air, alone, and under water, in the receiver of an air-pump, a circumstance which it was necessary always to attend to, in order to render the experiment availing.

A cavity in one of the crystals was pierced under oil, three under distilled water, and one under mercury. In all of them the fluid rushed in when the cavity was opened, and the globule of elastic fluid contracted so as to appear from six to ten times less than before the experiment. The fluid in all the crystals (in two it was minutely examined) was found to be water nearly pure, containing only a minute portion of the alkaline sulphates. The elastic fluid, as well as I could ascertain from the very minute quantities I could procure, appeared to be azote, unmixed with any other substance.

The largest cavity, which was in the crystal put into my hands by Prof. Buckland, contained a space equal to 74·5 grains of mercury; the water in it equalled in volume 48·1 grain measures of mercury; and the globule of air, after the experiment, equalled in diameter a globule of mercury weighing 4·2 grains, so that the elastic fluid had contracted at least between six and seven times.

In the other experiments, the cavities being much smaller the quantities of air and fluid could not be accurately measured; but there seemed to be nearly the same relation between the space

filled by fluid, and that containing aeriform matter; and in s of them the contraction of the globule of aeriform matter w: evidently greater, and in one instance to less than 1-10th of i original bulk.

The fourth crystal that I experimented upon was of unknow locality; but I have reason to believe that it was from Gu naxuato, in Mexico, as it strongly resembled some that M Heuland showed me from that place. The cavity in it w extremely small, and when pierced into, under distilled wat the globule of gas, from being one-eighth of an inch in diamete diminished so as to be less than 1-25th; so that its rarefacti was much greater in this than in the other instances; the wat was too small in quantity to be minutely examined; it seemed be nearly pure, producing a cloudiness barely perceptible solutions of nitrate of silver and muriate of baryta.

It was an interesting point to ascertain whether the sar circumstances occurred in productions found in rocks whi have been generally considered as of igneous origin, such as t basaltic rocks in the neighbourhood of Vicenza, the chalced nies of which so often afford included water. I found it mu more easy to make experiments of this kind, and to procu specimens, which were abundantly supplied to me from the sa sources as those I have just referred to; and though some these specimens proved to be permeable to the atmosphere, a to have been filled with water artificially, yet many occurred, which the sides of the cavity were absolutely impervious to or water.

The results that I obtained were very analogous. Water cc taining very minute quantities of saline impregnations, occ sioning barely a visible cloudiness in solutions of silver and muriate of baryta, was found to be the fluid; the gas was azo but it was in a much more rarefied state than in the rock cr tals, being between 60 and 70 times as rare as atmospheric a The quantity of water was to the void space in greater prop tion than in the rock crystals. In the instance in which t most accurate experiment was made; namely, on the great s cimen preserved in the collection of the British Museum, a which weighed 380 grains, the quantity of water was 29·9 grai the space occupied by aeriform matter was equal to 11·7 gra of water, the volume of the globule of gas at the common pr sure was to that of its rarefied volume as 1 to 63.

It occurred to me that atmospheric air might have been ori nally the elastic fluid included in these siliceous stones and in t crystals, and that the oxygen might have been separated fr the azote by the attraction of the water, and a direct experim

* I have not thought it necessary to refer to the heights of the barometer and t mometer in these experiments, as it is impossible to gain any other than ge results, upon quantities in which differences arising from atmospheric temperature pressure, would be quite unappreciable.

seemed to confirm this idea. A chalcedony which had been bored was placed in water free from air under a receiver, which was exhausted till a portion of gas from the interior of the crystal had escaped into a proper receptacle. This gas examined by nitrous gas was found to contain nearly as much oxygen as atmospheric air; so that there is every reason to believe that the water had emitted oxygen during the exhaustion.

I endeavoured to find some calcareous secondary rocks, or crystals belonging to them, containing cavities, on which experiments of the same kind might be made; but in a number of trials, I have as yet found none impermeable to the atmosphere; and the cavities of such, when bored, are always found to contain atmospheric air in a common state of density.

I was surprised to find that this was the case even with cavities in calcareous spar in the centre of a limestone rock; yet these cavities which contained atmospheric air did not fill with water when the stone was placed in water under an exhausted receiver. When, however, it was dry, and placed in a receiver alternately exhausted and filled with hydrogen, the air that was produced by piercing the cavities, was found mixed with hydrogen; proving that the substance of the stone was permeable to elastic fluid.

I hope soon to be able to make further researches on this subject; but in reasoning upon the vacuum, or rarefied state of the aeriform matter in the cavities of these rock crystals and chalcedonies, it appears difficult to account for the phenomenon, except on the supposition of their being formed at a higher temperature than that now belonging to the surface of the globe; and the most probable supposition seems to be, that the water and the silica were in chemical union, and separated from each other by cooling.

Water in the temperature of the arctic winter is constantly a crystallized body. As a fluid, its solvent powers are increased as its heat becomes higher, and, when elastic, the density of its vapour is exalted in proportion to its heat; so that an atmosphere of steam, supplied from an indefinite source above water, would render it capable of receiving a very high degree of heat. Lime retains water in combination at a heat above 250° Fahrenheit; baryta retains it (even under ordinary pressures) at a strong red heat, and fuses with it. It is extremely likely that a liquid hydrate of silica would exist, under pressure, at high temperatures; and like all liquid bodies in the atmosphere, would probably contain small quantities of atmospheric air; and such a supposition only is necessary to account for the phenomena presented by the water in rock crystal and chalcedony.

As, however, steam or aqueous vapour may be considered as having a share in these results, if it be supposed included in the cavity, no exact conclusions can be drawn from the apparent degree of contraction of the water; particularly as the late inge-

nious researches of Mr. Perkins show, that water is mucl
compressible than was formerly imagined; and the volu
water, however high its temperature, must be influenced
pressure to which it is exposed; so that a certain compr
weight may not only impede, but altogether counterac
expansive force of heat.

Many speculations might be indulged in on this subject,
shall not at present enter upon them; and I shall conclu
observing, that a fact, which has been considered by the I
nists, above all others as hostile to the idea of the igneous
of crystalline rocks, namely, the existence of water in
seems to afford a decisive argument in favour of the opin
has been brought forward to oppose.

APPENDIX.

Since the foregoing pages were communicated to the
Society, I have made some new experiments on the same
ject; all of them, except two, offered results of the same
as those I have detailed, and upon such I shall not enter
these two, from their peculiarity, will not, I trust, be th
unworthy of a particular notice.

In examining, with Mr. Heuland, the beautiful specime
rock crystals in the collection of Charles Hampden Turner,
I observed one crystal which, Mr. Heuland informed me,
from La Gardette, in Dauphiné, that contained a conside
cavity, in which there was a viscid brownish liquid, resem
in its appearance and consistence linseed oil. As the void
or cavity filled with aeriform matter appeared considerab
proportion to the fluid, I expressed a desire to pierce the cr
and Mr. Turner, hearing of my wish, was so kind as to gra
in the most polite and liberal manner, by presenting to m
specimen. With Mr. Newman's assistance I made the
experiments upon it. The cavity was pyramidal, and nearl
third of an inch in diameter. I soon ascertained that the
was not water, as it congealed and became opaque at a ter
ature of 56°. When the crystal was pierced under dis
water, the water rushed in and entirely filled the cavity, so
no other aeriform matter but the vapour of the substance
have been present: the water was rendered white and cl
apparently by the substance. I endeavoured to collect sor
it for chemical examination, but it was too small in quantity
equalling in volume one-sixth of the volume of the cavity),
submitted to analysis. It swam on the water, had no dis
taste, but a smell resembling naphtha; a portion of it take
mixed with the water, when exposed to heat acted like fixe
and it seemed to have a high temperature of ebullition
inflamed, producing a white smoke.

The fact, of almost a perfect vacuum existing in a cavity

taining an expansible but difficultly volatile substance, may be considered as highly favourable to the theory of the igneous origin of crystals: the other experiment is of a nature entirely different, though its result *may* be explained in the same supposition.

In examining a crystal in the collection of the Royal Institution, and which from its characters I believe to be from Capaó d'Olanda, Province of Minas Geraes, Brazil, I observed that the quantity of aeriform matter was unusually small in proportion to the quantity of fluid, in two or three cavities not occupying one-tenth or one-twelfth of the space; and from the peculiarity of its motion, it appeared to be more likely to be compressed than rarefied elastic fluid; and in piercing the sides of the cavities, I found that this was the case; it enlarged in volume from ten to twelve times; the fluid was water, but the gas was too minute in quantity to be examined.

It will be interesting to ascertain under what circumstances, and in what situations, crystals of this kind are found. If they be supposed of igneous origin, they must have been formed under an immense weight of atmosphere or fluid, sufficient to produce a compression much more than adequate to compensate for the expansive effects of heat, a supposition which, in consequence of Mr. Perkins's experiments, already alluded to, may be easily formed.

Article V.

On Grey Whin. By N. J. Winch, Esq.

(To the Editor of the *Annals of Philosophy*.)

DEAR SIR, *Newcastle-upon-Tyne, Dec.* 18, 1822.

Though I believe it to be generally known to such of your readers as have paid attention to the geology of Britain, that the workmen engaged in the collieries and quarries of the north of England and Scotland apply the term *whin* not only to basalt or greenstone, but to most other species of hard stone, yet I am not aware that a peculiar rock called by them *grey whin* has ever attracted particular notice. The rock constituting the stratum, or possibly strata in question, consists of minute grains of hair-brown compact felspar or clinkstone, with a few spangles of silvery mica scattered through it. From the close cohesion of its small particles, it might be mistaken at first sight for clinkstone, strongly resembling the well-known rock of Lamlash, but by a lens, the granular texture is detected, and the difference between them easily proved. Owing to this compact texture,

and the nature of its component parts, it is both heavy and tough, requiring a smart blow of the hammer to break it. Before the blowpipe, it fuses without much difficulty, into a pale-brown glass; it is not magnetic like basalt. At St. Anthon's colliery (see Geological Transactions, vol. iv. p. 41), the bed lies nearly 104 fathoms from the surface of the earth, and is a foot in thickness; its situation is between a stratum of strong white post (sandstone) seven feet thick, and a stratum of blue metal (shale, slate clay) eight and a half feet thick. In Walbottle Dene, five miles west of Newcastle, a similar stratum creeps out by the edge of the brook; but its thickness or relative position cannot there be so accurately ascertained as at St. Anthony's, where a shaft has been sunk through it. Whether this be a continuation of the same bed, I cannot determine; but the high main coal cropping out at Benwell Hills, two miles to the east of Walbottle, and this bed lying 29 fathoms below that seam, I am inclined to consider them one and the same, notwithstanding the stone is finer grained at the latter place; for all our coal strata rise to the clay in succession towards the west and south-west.

It is by no means improbable that similar beds may be known to exist in other districts; but never having heard of a stratum of compact felspar and mica, *as a member of a coal formation*, you will oblige me by giving publicity to this short notice through the medium of your journal.

I have the honour to be, Sir,
Your most obedient servant,
N. J. WINCH.

ARTICLE VI.

Queries on the Plumbago formed in Coal Gas Retorts.
By the Rev. J. J. Conybeare, MGS.

(To the Editor of the *Annals of Philosophy*.)

MY DEAR SIR, *Bath Easton, Dec. 15, 1822.*

THE very general use of coal gas, and the degree of scientific information mostly to be found in those connected with its manufacture, render it probable that for many persons the remarks which I am about to offer will possess but little of novelty. As, however, I am not aware that this subject has yet been noticed in any periodical or other publication, I venture to intrude them on the notice of your readers, rather indeed in the hope of obtaining further information from those who are more competent than myself, than of adding much to the public stock,

The cast-iron retorts used in the Bath gas works, being, on an average, somewhat less than one inch and a quarter in thickness, are *burned through*, as it is technically termed, in the part exposed to the greatest heat, in about 18 months. After this they are of course no longer serviceable. This destruction is effected by the progressive oxidation and scaling off of the metal. The scales consist chiefly of peroxide of iron, and the powder which they afford by grinding and washing might be applied to any of the purposes for which the *crocus martis* is in request. It is observable that the portion of cast-iron which remains unoxidated in the parts exposed to a strong heat is found to present, on being broken, a texture much more highly crystalline than that of the portion further removed from the action of fire.* Is this simple development, or is it to be ascribed to that mysterious re-arrangement of particles which in some other cases appears to take place at a heat short of actual fusion?

The unserviceable retorts on being withdrawn from their beds are found lined with a coating of plumbago averaging the thickness of four inches. This coating is thickest towards the bottom of the retort, nearer to its mouth it becomes scantier and more intermixed with coaly and fuliginous matter. The general aspect of the predominant variety may be thus described: *Colour*, iron-grey, somewhat lighter than that of native plumbago; *texture*, scaly; *structure*, mammillated, usually in very close aggregation; some specimens exhibit this structure on the larger scale; generally it is discoverable only by the use of the lens; *hardness*, somewhat variable, but always greater than that of the best native plumbago; scratches gypsum, but is scratched by calc-spar; *lustre* of the exterior surface (especially where the mammillated structure is distinct), sometimes very considerable: *lustre* of the fracture usually but small: the *powder* uniformly resembles that of common plumbago, excepting that it is somewhat less brilliant.

In another variety, the structure of the mass is stalactitic, and its texture, where broken, perfectly compact and uniform; even under the lens, this variety closely resembles some of the stalactitic grey ores of manganese, and occasionally exhibits on the surface a considerable degree of iridescence. The mass for the greater part gives evidence of its gradual formation, by its slaty aspect, and tendency to break with greater readiness in the direction of what may be termed its strata. In many parts, it is rifty, and the rifts are usually coated with a brilliant deposition of a lighter colour than the general mass. Fragments projected

* For this observation, as well as for most of the facts contained in this letter, I am indebted to the kindness of Mr. Eastwick, the intelligent and obliging superintendent of the Bath Gas Works.

on nitre deflagrate, but not rapidly, leaving after combus traces of iron. Some rude experiments gave me reason to th that the quantity of iron varied in different specimens, and it scarcely amounted, at the most, to the nine per cent. sta by Berthollet to exist in native graphite. That the substa in question is a true artificial plumbago admits, I apprehend, no doubt. It must be formed plentifully in many other works besides those of Bath, and must, therefore, in all proba lity have attracted the notice of persons far better able to inqu into its production and properties than myself. In our works has not yet been converted to any useful purpose. In writing drawing, its hardness and general want of compactness rene it in its crude state altogether unserviceable. When finely po dered and washed, it might be used in composition pencils. F the domestic uses to which plumbago is applied in coati grates, &c. I have found it to answer sufficiently well; but it objected by the *savantes* in housewifery, that it has not a suf cient *lustre*, and would, therefore, I suppose, be seldom used b them; but where preservation only, and not ornament, was th object,* I have been informed that it has been applied with suc cess to the purpose of covering razor strops. For that of dimi nishing friction, and for the manufactory of crucibles, furnace &c. it would, I should apprehend, answer sufficiently well, for th latter especially. It appears from a paragraph in the articl Coinage (Supplement to Encyclopædia Britannica), that the blu pots used in the mint are all of foreign manufactory, those made in this country containing *too small* an admixture of black lead. Is this to be attributed to the scarceness of that material, or to the want of sufficient tenacity in the English clay with which it is worked up, rendering its addition beyond a certain point impracticable?

But whether this substance prove useful or worthless in an economical view, its occurrence cannot fail to strike the more speculative inquirer as adding one more to the many instances in which the unintentional products of art have been found to resemble those of nature, and as contributing, remotely at least, to throw fresh light upon one of the most controverted points of geological theory. Plumbago is well known to be among the most *infusible* of mineral substances. Now in the present cases, if not the whole of its mass, at least all those portions in which the mammillated structure is discernible, and yet more its stalactitic form, must have been brought to a state of fusion by a heat inferior to that at which cast-iron begins to run. Will this be

* I know not at what price it might be rendered, but as its production is matter of necessity, and it is at present considered as useless, the charge could scarcely be high. The retail price of the black lead of the shops is 2*s.* per lb. and it is said to be much adulterated by the admixture of a micaceous hæmatite obtained near Bovey Tracey (C. Devon), which must be injurious to its preservative qualities.

the better accounted for by the long duration of the heat, or by assuming that this compound, like some others, is more fusible at the moment when its constituents first enter into chemical union. Should it be apprehended that no *actual fusion* whatsoever has taken place, the formation and consolidation of the substance by heat without fusion will still furnish the vulcanist with a new point of analogy.

Believe me, my dear Sir, very truly yours,

J. J. Conybeare.

P. S. The character of some portions of this plumbago has struck me as not unlike that ascribed to the points of charcoal altered and fused by voltaic electricity, in some late American experiments.

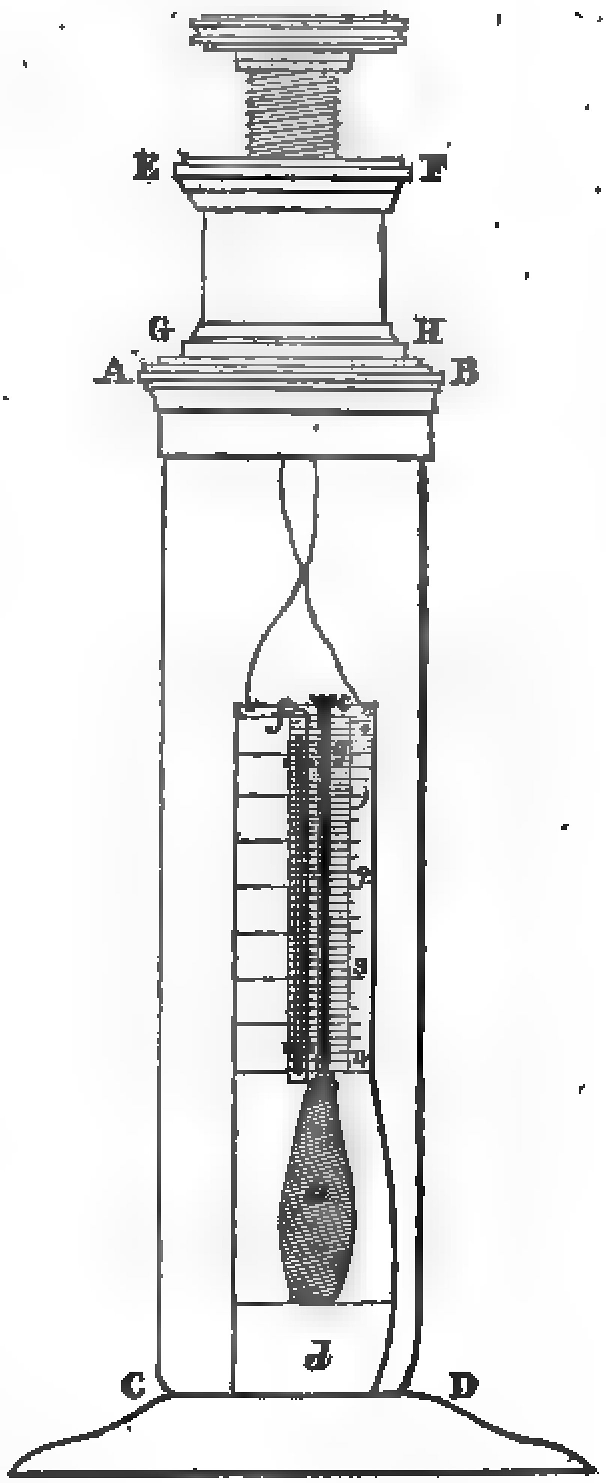
Article VII.

On the Compressibility of Water. By Prof. Oersted.*

Prof. Oersted, several years since, laid before the Royal Society of Copenhagen some experiments on the compression of water, and showed at that time that this might be effected by a much smaller power than is generally supposed, provided the instrument was constructed according to the well-known principle, that a pressure acting upon a small surface of an enclosed liquid had the same effect as a power equally great, acting upon each similar part of the whole surface. For the compression of water he made use of a large cylinder of brass upon which one smaller was screwed, furnished with a well-fitted piston. He was, therefore, able to show the compression of water by a small power, quite as well as Abich and Zimmermann had done by many hundred pounds weight. To measure the power, a tube full of air, which was confined by mercury, was used, by which contrivance, of course, the air underwent the same pressure as the water from which it was separated by the mercury. According to the principle, that the compression of the air is in proportion to the pressing power, it was easy to calculate this power. But notwithstanding the great strength of the brass cylinder in which the water was compressed, it was possible that it might have given way, so that not only the compression of the water might have been measured, but a result obtained, in which the flexibility of the instrument

* Extracted from a memoir read before the Royal Society of Copenhagen, 1822.

was included. In the first experiment of M. Oersted, as we in all those of former philosophers, Canton only excepted, change of temperature, which might have happened during experiment, had not been taken into consideration, which, h ever, in several respects was necessary, as it might even be s posed that heat was produced by the very compression. excellent experiments of Canton, which, in later times, h been almost forgotten, were made with the pressure of conden and rarified air. But every condensation or expansion of ai accompanied with an adequate elevation or diminution of te perature; it was, therefore, to be feared, that this ingenious p losopher had been deceived by this influence. He found t compression of water, at a pressure, equal to that of our atn sphere, to be between $\frac{44}{1000000}$ and $\frac{48}{1000000}$ of the bulk of t water. The experiments of Canton possessed a great advanta over all which have recently been made, viz. that the vessel whi contains the liquid to be compressed undergoes the same pre sure both internally and externally; so that neither its form n its size can be altered. Within a few years, Mr. Perkins, tl ingenious inventor of the siderographia, has made some exper ments, which have the same advantage as those of Canton; h included the tube of metal in which the water was to be com pressed, in water which was exposed to the same pressure. Hi ingeniously contrived experiments will always be of considerabl importance, because he has made them with a power which a philosopher seldom has at his disposal, viz. a pressure severa hundred times exceeding that of our atmosphere. It was not however, his intention to ascertain by these experiments, whether heat was produced by the compression of water, and what influence it had upon the result. Prof. Oersted endeavoured, therefore, to contrive an instrument which allowed an exact measurement of the compressing power, as well as of the compression of the water itself, and which at the same time made it easy, exactly to ascertain the influence which heat might have on the effect. The water which is to be compressed is included in a glass tube, *a*, which holds about two ounces of water: it is closed below, and its upper part terminates in a capillary tube, *bc*, 52 French lines long, and of even bore, so that the vessel is like a flask, the neck of which is a long capillary tube. On the upper end of this tube is a small funnel two lines wide. The flask holds 709·48 grammes of mercury, but the mercury which fills 24·6 lines of the capillary tube weighs only 96 milligrammes, which gives $\frac{55}{10000000}$ for the length of a line, or, to be more exact, 0·000005501 of the contents of the flask. When the experiment is to be made, the flask is warmed a little by being kept for a moment in the hand; if possible the temperature must not rise above $\frac{1}{4}°$ centigrade. Then a drop of mercury is introduced into the funnel, which, while the water in the flask is



cooling, will partly sink into the capillary tube *f*, as deep as the mark *g*, and separate the water in the flask from that in the outer vessel. This flask is now placed into a strong cylinder of glass A B C D, upon which another smaller cylinder of brass EFGH is fixed. A piston connected with a screw F is moveable in this upper cylinder. If a pressure by means of this piston be exerted upon the water in the glass cylinder, this will press upon the mercury, and thus upon the water in the flask. As soon as the water in the flask is compressed, the mercury in the capillary tube will sink; and the least pressure produces that effect. To measure the compression, the author fastens the flask in a cylinder of lead *d*, which bears a scale on which one-fourth part of a French line is marked, and a small glass tube, *e f*, filled with air, evenly bored, serves to measure the compressing power by the compression of the air. All changes of temperature are easily perceived on the narrow neck of the flask much more accurately than on any thermometer; for an increase of temperature amounting to one degree (centigrade) makes the water rise 27 lines, its temperature supposed to be about 15°. If the temperature is considerably higher or lower, the changes of course will be either greater or smaller. The scale being divided into one-fourth part of a line, and one-eighth being easily perceived by the eye, it is evident that $\frac{1}{100}$° cannot escape observation, and that $\frac{1}{207}$ is by no means difficult to observe. It is scarcely necessary to add, that the temperature of the liquid is to be ascertained by a thermometer, at the beginning of the experiment. If the experiment be made quickly, and no per-

sons present beside the observer, the difference in the height of the mercury before and after the experiment will generally be one-eighth of a line; frequently, however, one-fourth. In the first case, it announces a change of temperature amounting to not quite $\frac{1}{200}°$, in the second to hardly $\frac{1}{100}°$. If the experiment be performed slowly, the difference may be one-half, and even one line. In every case the mean height between these two observations is to be taken. By a long series of experiments, of which the most accurate were made at a temperature of 15—16°, a pressure equal to one atmosphere has produced a compression = 0·000047 of the original bulk of the compressed water. Several alterations on the pressure, from one-third to five atmospheres, were tried, and agreed in proving, *that the compression is in direct proportion to the compressing power.* The same result had been deduced by the author from his former experiments, which, however, were influenced by the giving way of the metallic vessel; the expansion of which must likewise be in proportion to the pressing power.

It seems pretty evident that no heat is produced by this condensation of the water, the limit between mercury and water being, after the experiment, on the same place as before; the insignificant elevation of temperature must be considered as a necessary result of the contact of the observer during the experiment. Even after a pressure of five atmospheres, the difference of temperature was not quite $\frac{1}{100}°$, and in general neither greater nor less than that, if only a pressure of one atmosphere had been used. It was, however, possible, that the expansion of the water when the pressure had ceased, would absorb the heat produced before by the compression; therefore a thermometer of Breguet, on which a difference of $\frac{1}{10}$th of a degree may easily be perceived, was placed in the water in the large cylinder, and exposed to the greatest compression which could be procured, but not the least trace of any change in the temperature was observable. The manner in which these experiments of Prof. Oersted agree with those of Canton is really interesting. The English philosopher had at 64° Fahr. = $15\frac{1}{2}°$ centigrade, a compression of $\frac{44}{1000000}$ by a pressure equal to one atmosphere, and at 34° Fahr. = $1\frac{1}{10}°$ centigrade, it was $\frac{49}{1000000}$. This rather unexpected result may easily be explained by small differences in the temperature, but it does not, on either side, deviate much from the result Prof. Oersted obtained, which was $\frac{47}{1000000}$.

Article VIII.

Astronomical Observations, 1822.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Nov. 21. Immersion of Jupiter's first satellite	16h	14′	49″	Mean Time at Bushey.
	16	16	10	Mean Time at Greenwich.
Nov. 23. Immersion of Jupiter's first satellite	10	43	19	Mean Time at Bushey.
	10	44	40	Mean Time at Greenwich.
Nov. 25. Emersion of Jupiter's first satellite	7	21	20	Mean Time at Bushey.
	7	22	41	Mean Time at Greenwich.
Nov. 27. Emersion of Jupiter's second satellite	9	50	15	Mean Time at Bushey.
	9	51	36	Mean Time at Greenwich.
Nov. 29. Immersion of Jupiter's third satellite.*				
Dec. 7. Emersion of Jupiter's first satellite	16	41	20	Mean Time at Bushey.
	16	42	41	Mean Time at Greenwich.
Dec. 11. Emersion of Jupiter's second satellite	15	04	00	Mean Time at Bushey.
	15	05	21	Mean Time at Greenwich.

Article IX.

Analysis of Uranite from Cornwall.
By Richard Phillips, FRS. L. & E. &c.

This mineral has been found in several of the Cornish mines; the crystals are sometimes of a yellow colour, more especially those which occur in Tin Croft copper mine, near Redruth; while in Gunnis Lake copper mine, at the eastern extremity of the county, it is met with of a beautiful deep-green colour.

The primary crystal of this substance is a right square prism, and there is no difference in this respect between the yellow and green crystals; the modifications of this form, with their varieties, have been described by my brother (Mr. W. Phillips), in the third volume of the Geological Transactions.

Both varieties of uranite have been subjected to chemical examination by the late Rev. Mr. Gregor. With respect to the yellow crystals, he states (Phil. Trans. 1805), that beside oxide of uranium, they contain some lime, silica, and oxide of lead; and, he observes, that "the green crystals differ in no respect

* According to the Nautical Almanac, the immersion of this satellite should have taken place at 17h 26′ 56″; but although I placed the telescope at 17h 09′ 29″, the eclipse had previously occurred.

from the yellow, except in containing a little of the oxide of copper." This opinion is confirmed by the identity of the crystalline form already noticed; Mr. Gregor states, however, that he had not a sufficient quantity of the crystals to allow of subjecting them to a rigorous examination. Since this period, Mr. Gregor has given an analysis of the green crystals in the fifth volume of the *Annals*, according to which they consist of

Oxide of uranium, with a trace of oxide of lead..	74·4
Oxide of copper	8·2
Water	15·4
Loss	2·0
	100·0

M. Berzelius, in his Nouveau Système Mineralogique, has given an analysis of the uranite of Autun: he says, "I have found that this mineral is a compound of oxide of uranium, with lime and water; in fact, that it is a true salt with a base of lime in which the oxide acts as an acid." He further states, that the oxygen of the uranium is three times, and that of the water six times, the oxygen of the lime; there is, however, he observes, a slight excess of oxide of uranium and of water. The results of this analysis are thus stated:

Lime	6·87
Oxide of uranium	72·15
Water	15·70
Oxide of tin	0·75
Silica, magnesia, oxide of manganese.	0·80
Matrix	2·50
	98·77

"The same mineral," continues Berzelius, "is met with in Cornwall, but it is of a very fine deep-green colour; this colour is owing to the presence of a certain quantity of arseniate of copper, which is an accidental admixture. When this uranite is treated with soda by the blowpipe, it gives white metallic globules, composed of arseniuret of copper."

With the intention of procuring some peroxide of uranium, I dissolved a quantity of the green uranite in nitric acid; the oxide of uranium was precipitated by ammonia, and the oxide of copper dissolved by excess of it. In order to free the oxide of uranium from any arsenic acid which it might contain, I boiled the precipitate in a solution of potash; on adding a portion of the filtered solution to nitrate of silver, an abundant yellow precipitate was formed, which had the appearance of arsenite of silver; but as arsenious acid does not, I believe, exist in nature combined with any metallic oxide, and as also the mineral in

question had been dissolved in nitric acid, it was evident that the yellow precipitate could not be arsenite of silver.

As phosphoric acid is well known to afford a yellow precipitate with oxide of silver, I suspected the presence of this acid, and I found that the alkaline solution gave a blue precipitate with sulphate of copper; and when it was saturated with an acid, mixed with ammonia and muriate of magnesia, the well-known minute crystals of phosphate of ammonia and magnesia were formed.

Under these circumstances, it appeared to me worth while to subject the uranite to another analysis, and I proceeded as follows:

One hundred grains of the green uranite of Cornwall were dissolved in dilute nitric acid; half a grain of silica remained undissolved. In attempting to saturate the solution previously to adding nitrate of lead for the separation of the phosphoric acid, I found that precipitation occurred long before sufficient potash had been added. As this free nitric acid would dissolve the phosphate of lead formed, I decomposed the nitric solution by boiling it with excess of potash, and then having added excess of acetic acid to the alkaline solution, nitrate of lead gave an abundant precipitate of phosphate. I prefer acetic acid for this purpose to nitric, because as acetic acid has scarcely any action upon phosphate of lead, it is not requisite to take the trouble of avoiding slight supersaturation.

The phosphate of lead thus obtained, after washing and drying, weighed 80 grains, equivalent, according to Dr. Thomson, to 16 grains of phosphoric acid; the oxides of uranium and copper were redissolved in nitric acid, and the solution being added to ammonia, the oxide of copper was dissolved, and that of uranium precipitated; the latter, after washing and drying, weighed 60 grains, and the oxide of copper, after ebullition with potash, weighed 9 grains. The ammoniacal solution contained no lime. It appears, therefore, that 100 grains of this substance contain

Silica	0·5
Phosphoric acid	16·0
Oxide of uranium	60·0
Oxide of copper	9·0
Water	14·5
	100·0

I attempted to determine the quantity of water by direct experiment; for this purpose 50 grains of the mineral were heated on a platina crucible by a spirit lamp, 8·5 grains were lost = 17 per cent. This experiment was repeated with a precisely similar result, and no further loss was occasioned by exposing the mineral to a strong red heat. If, however, we add 17 to the acid and oxides, there will be an excess of 2·5 over

the 100 grains submitted to analysis. Suspecting, therefore, that some phosphoric acid had been volatilized with the water, I held litmus paper over a further portion of the mineral while subjected to the heat of the lamp; I found that it was reddened during the expulsion of the last portions of the water, and turmeric paper, which had been reddened by ammonia, had its yellow colour restored by the phosphoric acid thus volatilized.

M. Berzelius, it has been already stated, attributes the green colour of this mineral to the presence of arseniate of copper. In order to examine this point, Mr. Children was good enough to submit some crystals to the blowpipe while I was present. When crystals without admixture were heated upon charcoal, not the slightest arsenical smell could be perceived by either of us; but when the ore was pulverised and mixed with bicarbonate of soda, and strongly heated in the reducing flame on charcoal, a slightly arsenical smell was discoverable, but no fumes were visible. As, however, this ore contains so large a portion as nine per cent. of oxide of copper, the arsenic acid, combined with it, would be detected with the greatest facility.

Still further to examine whether the oxide of copper is in combination with arsenic acid, I supersaturated some of a nitric solution of the mineral with ammonia. By this the arseniate of copper would be dissolved, and the phosphate of uranium precipitated without decomposition. I boiled some of the ammoniacal solution with potash, and added nitrate of silver to the filtered solution; a yellow precipitate was obtained having a scarcely perceptible tinge of red, instead of being of a deep-red colour, as would have occurred if arsenic acid had been present in sufficient quantity to form arseniate with the oxide of copper. It is, therefore, evident, that the oxide of copper is in the state of phosphate, a circumstance which is likely to occur, when it is known that the mine which produces the uranite also yields phosphate of copper.

It is difficult to determine in what state of oxidation the uranium exists in the mineral; but as it is acted upon during analysis by nitric acid, and as I found by direct experiment that when dissolved in nitric acid, and heated to redness, it gained no weight, I think we may conclude, that it is procured in the state of peroxide, and I shall consider it as existing in this state in the ore.

According to Dr. Thomson, hydrogen = 1; the atom of peroxide of uranium is represented by 137, and that of phosphoric acid by 28; 60 will, therefore, combine with 12·2 of phosphoric acid, forming 72·2 of phosphate of uranium, and there remain 3·8 of phosphoric acid to combine with 9 of peroxide of copper; but as phosphate of copper is composed of 80 oxide and 28 acid, or 1 atom of each, 9 of oxide will combine with only 3·1 of acid, leaving an excess of 0·7.

Supposing the phosphate of uranium to be combined with three atoms of water, and the phosphate of copper, as deter-

mined by Mr. Lunn,* with two atoms, the mineral will appear to consist of

Silica	0·5
Phosphoric acid	15·3
Oxide of uranium	60·0
Oxide of copper	9·0
Water	13·8
	98·6
Loss	1·4
	100·0

Neglecting the silica, we may consider the ore as essentially composed of nearly

Phosphate of uranium	73·2
Phosphate of copper	12·3
Water	14·5
	100·0

On comparing the results of this analysis with those obtained by Mr. Gregor, it will be observed, that the quantity of phosphate of uranium in 100 parts of the mineral differs only 2·2 from the weight of what he considered to be pure oxide of uranium. It is indeed evident that in his mode of operating, he precipitated, dried, and weighed the acid and oxide in combination.

M. Berzelius seems to admit that the only material difference between the uranite which he analyzed and the green variety, arises from the accidental admixture of the latter with what he supposed to be arseniate of copper; when also it is observed that what he estimates as oxide of uranium, agrees in quantity with the phosphate in the green variety as nearly as 72·15 to 72·2, little doubt can be entertained that the mineral from Autun, as well as that from Cornwall, is essentially composed of phosphate of uranium.

* *Annals*, vol. iii. New Series, p. 179.

Article X.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

On Saturday, Nov. 30, being St. Andrew's Day, the Royal Society held their anniversary meeting at Somerset House. A great number of members were in attendance at 12 o'clock, when the chair was taken by the President, Sir H. Davy, Bart.

In the course of business, Sir Humphry announced the names of the Fellows lost to the Society by death since the last anniversary; among whom were Sir H. C. Englefield, Bart.; Sir W. Herschel, Dr. Marcet, Rev. Mr. Vince, Plumian Professor of Astronomy at Cambridge, Dr. C. H. Parry, Sir C. Pegge: and among foreign members, M. Delambre, the Abbé Haüy, and Count Berthollet. He gave a new interest to this ceremony, by entering into a brief but elegant and discriminating tribute to the scientific merits of these distinguished individuals. He prefaced his eulogies by observing, that the occasion was a particular one—that the Society had never before lost in one year so many distinguished fellows—that the respect paid to the memory of the illustrious dead might, he hoped, awaken a feeling of emulation among the living; and that although he was unable to do justice to their respective merits, yet he trusted that in all he should have to say, the judgment and the feelings of the Society would be in unison with his own.

Sir H. C. Englefield, said he, was an accomplished gentleman, gifted with a great variety of information, and possessing considerable talents for physical research. His knowledge of astronomy was evinced by his early work on Comets: he was a clear writer—a learned antiquarian—eminently distinguished for conversational powers—a truly honest man—and an ornament to that class of society in which he moved.

Of Sir William Herschel it was observed by Sir Humphry, that the progress of modern astronomy was so connected with his labours, that his name would live as long as that science should exist: his happy and indefatigable spirit of observation was spoken of as proved by his discovery of a new planetary system, and of a number of satellites before unknown—his inductive powers of reasoning, and bold imagination, as shown in his views of the stellar systems in the heavens—and his talents for philosophical experiments, as proved by the discovery of the invisible rays in the solar spectrum. He was a man, continued the eulogist, who, though raised by his own efforts—by the power of his own intellect, to so high a degree of eminence, was spoiled neither by glory nor by fortune; and who

retained, under all circumstances, the native simplicity of his mind. His amiable character and the felicity of his life were dwelt on at some length. He died full of years and of honours; and, when unable to labour himself, saw a kindred disposition and kindred talents displayed by his son. In conclusion,—his mental powers seemed to have acquired such a degree of expansion here, as to have become incapable of further elevation or extension but in a higher stage of existence.

Sir Humphry then expressed his regret at the premature death of Dr. Marcet, whom he characterized as an ingenious and accurate chemist—a learned physician—a liberal, enlightened, and most amiable man.

Appropriate characters were likewise given of Mr. Vince, Dr. Parry, and Sir Christopher Pegge.

In eulogising the foreign members, the name of Haüy was spoken of as one that would always be remembered in the history of mineralogy, in consequence of his having established what may be considered as a mathematical character in discriminating mineral species. Delambre, the learned Secretary of the Royal Academy of Sciences of Paris, was mentioned with great praise as an excellent astronomer, and candid and liberal historian of his own science; and an able observer, whose name will be for ever associated with the first very accurate measurement of an arc of the meridian in France. M. Berthollet was called by Sir Humphry the patriarch of modern chemistry. He dwelt on his discoveries and labours at some length; and paid a just tribute to the candour and liberality of his mind—to his warm and zealous patronage of rising genius, and to his quiet and amiable social virtues.

The President next read the list of members admitted into the Society since the last anniversary, among whom were Mr. Dalton, of Manchester; Dr. Kidd, of Oxford; Mr. James Thomson; and Mr. Rennie.

He then proceeded to state the decision of the Council respecting the award of the medal on Sir Godfrey Copley's donation, which, he announced, had been adjudged this year to the Rev. W. Buckland, Professor of Mineralogy and Geology in the University of Oxford, for his paper, on the Fossil Bones and Teeth discovered in a Cave near Kirkdale, in Yorkshire, printed in the Society's Transactions.

Prior to delivering the medal to Prof. Buckland, as the present was the first time that a paper on a subject of pure geological research had been honoured by this mark of distinction, Sir H. Davy gave, in an eloquent discourse, a concise view of the history and importance of geological pursuits in general, as well as of the interest and value of Mr. Buckland's recent labours in particular. Of this discourse, we are happy to present a condensed epitome.

While the phænomena of the distant stars and other objects

of astronomical science had long been subjects of investigation, in consequence of their relations to the seasons and to time, the structure of the earth had been scarcely noticed until a late period. Cosmogonies, "or dreams of the formation of the world," had been brought forward at various periods, and some general views in geology had been advanced by Hooke, Lister, Strachey, and other early members of the Royal Society, or contributors to its Transactions; but the commencement of geology as an exact science did not take place until about 50 years since, when a regular classification of minerals having been effected, Pallas, De Saussure, and above all, Werner, further arranging this, the alphabet of geology, proceeded to read with it that part of the book of nature; and the logic of the science was subsequently furnished by chemistry and comparative anatomy. The space of a discourse would not admit even of naming the labourers, our contemporaries, by whose zeal and accurate spirit of observation, the field of geological research had been so successfully cultivated within the last 20 years; but among them that of Prof. Buckland was highly distinguished by his indefatigable ardour for inquiry, and by his caution and sagacity in drawing conclusions.

For the purpose of illustrating the subjects of Mr. Buckland's paper, Sir Humphry now gave a general view of the constitution of the superficial part of the globe, of the arrangement of its constituent rocks, and the distribution in them of organic remains: in this he mentioned that he had himself ascertained that those remains of the animal kingdom, the position of which was geologically the lowest, contained the least quantity of the original matter of the animals. Although it had been strongly suspected that the large animals of the elephant, rhinoceros, hippopotamus, tiger, hyæna, and other kinds, the remains of which are met with in the diluvian strata, were once inhabitants of the countries where their bones and teeth are thus found, yet this had never been distinctly proved until Prof. Buckland described the Yorkshire cave, in which several generations of hyænas must have lived and died. By the industry and happy talent for observation of that gentleman, there had been distinctly established an epoch from which to trace the revolutions of the globe. Sir H. had himself since visited the cave, in company with Mr. B. and could testify to the accuracy of his description;—announced that the Professor had recently examined a number of similar caverns in Germany, and that by the phænomena of these, he had found his former conclusions confirmed. Sir H. then expressed his hopes that Mr. Buckland would communicate the results of his late researches to the Royal Society. Two theoretical views might be taken respecting the animal remains in question; one, that the animals had been of peculiar species fitted to inhabit temperate or cold climates; thus, that the elephant and rhinoceros of Britain might have

been as different from those of tropical regions as our common cattle are from the musk ox of Siberia: in the other hypothesis, the globe was considered to have undergone a change of temperature. Sir Humphry was of opinion that the latter supposition is the most probable one: if the former were to be adopted, it would be difficult to conceive how the elephants could obtain sufficient food in polar climates, or how the hippopotami could have inhabited their frozen lakes. He then entered into some general views on this interesting subject, and its connexion with that of the chaotic state of the globe, and with those of the successive creations of living beings, and the early revolutions of our planet, until it became at last fitted for the habitation of man.

In presenting the medal to Prof. Buckland, the President desired him to receive it as a tribute of respect from a body, which he believed to be very impartial in its decisions, and which considered the actual advances that had been made in science, rather than the nation, school, or individual, by whom they had been effected. Sir Humphry expressed his hopes that Mr. B. would enjoy health to continue his researches, and that his example would stimulate other members of the Society to similar inquiries and labours; for that geology was abundant in objects of research, and was most worthy of being pursued, on account of its connexion with the useful arts, of the happy views which it affords of the order of nature, and of the assistance which it lends to true religion.

Sir H. considered that the scriptural account of the deluge was now completely established from geological grounds; but the science of geology, he maintained, should be studied in a manner altogether independent of the authority of the Sacred Scriptures; for that these, as Bacon had said long before, merely gave some remarkable facts in the history of the globe, and not systems of philosophy;—the latter were left to be framed by the industry of man, and by the exercise of his god-like faculty of reason, which, in its highest sphere, approximates to revelation itself. The discourse was concluded by some appropriate moral reflections arising out of the subjects discussed.

The Society then proceeded to the election of their officers and council for the year ensuing, when the following gentlemen were chosen.

President.—Sir Humphry Davy, Bart.

Treasurer.—Davies Gilbert, Esq. MP.

Secretaries.—William Thomas Brande, Esq. and Taylor Combe, Esq.

Of the Old Council.—Sir H. Davy; W. T. Brande, Esq.; Samuel Goodenough, Lord Bishop of Carlisle; Taylor Combe, Esq.; Davies Gilbert, Esq.; Charles Hatchett, Esq.; J. F. W. Herschel, Esq.; Sir Everard Home, Bart.; John Pond, Esq. Astronomer Royal; William Hyde Wollaston, MD.; Thomas Young, MD.

Of the New Council.—Charles Babbage, Esq.; Sir Gilbert Blane, Bart.; Charles, Lord Colchester; J. W. Croker, Esq.; John, Earl of Darnley; Sir Henry Halford, Bart.; Charles Hutton, LLD.; Capt. Henry Kater; W. H. Pepys, Esq.; Joseph Sabine, Esq.

The weekly sittings of the Society had been resumed on the 7th of November, and had taken place twice afterwards prior to the anniversary meeting. On the 14th, a paper by the Astronomer Royal was concluded, entitled, "An Appendix to a former Paper, on the Changes which appear to have taken Place in the Declination of some of the principal fixed Stars." Mr. Pond stated in this paper that he had obtained results confirming those given in his last communication.

A paper, by the same gentleman, was also read, "On the Parallax of α Lyræ." In this, the absolute parallax of the star in question was stated to be a very small fraction of a second.

Nov. 21.—The Croonian lecture was commenced, entitled, "Microscopical Observations on the Suspensions of muscular Motion in the Vibrio Tritici," by Francis Bauer, Esq. FRS.

Dec. 5.—The Croonian lecture was concluded. The curious animal described in this paper is the cause of a particular disease in wheat, at first thought to be peculiar to Kent, and was discovered by the author in 1807 while engaged in the investigation of the various diseases to which that species of corn is subject. In the ears diseased by it, some grains were quite ripe and dry, while others, quite green, were unimpregnated germs. They contained cavities lined with a fibrous substance, every fibre of which was a very minute worm. These worms which, when moistened, were in active motion, after being dry, and apparently dead for five days, when again moistened, were in active motion as before. Mr. Bauer conceived that their spawn or eggs must have been introduced into the germs by the sap, as he had ascertained was the case with the minute fungi which produce in wheat the disease called *smut*. He sowed some infected grains, and some with the smutty infection in addition; and in the ears subsequently produced from them found both diseases co-existing; the eggs in these ears, he found, were of the third generation.

The worms are annulose; have a proboscis of four or five joints, which they extend like an opera-glass; and have a clawed tail. They are rather opaque on the back, but more transparent on the belly, through which are seen in them whole strings of eggs. Near the tail is a circular aperture with a fleshy rim, through which their eggs are exuded in strings of six or seven at a time; as each egg comes forth, the tail is elevated with a quick motion. The eggs (or rather envelopes of the fœtal worm) are in some degree transparent, and appear to be truncated at first; but they soon emit water, and assume an oval figure, a little narrowed in the middle; they are about

1-300th of an inch in length, by between 1-800th and 1-900th in width; in one hour and a half after exudation, the young worm peeps out, and by twisting about, and other active exertion, wholly extricates itself in about an hour more. The worms just extricated from the eggs look like fine glass tubes full of water, with air-bubbles corresponding to the annuli of the older ones, but no indentations. The large egg-bearing worms, which were one-fourth of an inch long by 1-80th wide, have no other motions than those of moving their heads and tails; they present no external marks of sex, and are considered to be hermaphrodites. In the grains which also contained smut, there were two or three large worms surrounded with eggs.

Some of these worms were revived in wheat which had been dry for five years and eight months; the longest period of reviviscence observed, was six years and one month; the large worms do not revive. If kept in water longer than 35 days, they all die, and become as straight as needles, but remain a very long time without decaying. If merely kept moist in a watch-glass, they may be kept alive for three months; if too much water be applied to them, they cannot be so readily revived as when a little is used, which soon evaporates; and the longer their periods of desiccation have been, the longer they require to be kept moist for reviviscence. They appear to be preserved by a mucus in which they are imbedded, and which appears to be of an oily nature. This, however, remains for years when the worms can no longer be revived.

Mr. Bauer had completed his investigation of the vibrio tritici in 1810, and conceived that it had not been noticed before, when he met with some references to former descriptions of it; these, however, being very vague, and his time having been since occupied with researches of a different nature, he had no opportunity of consulting the authors referred to until lately: upon so doing, he found no occasion to alter any of his conclusions on the subject.

Dec. 12.—On Metallic Titanium, by W. H. Wollaston, MD. VPRS.

This paper commenced with a review of the results hitherto obtained in experiments on the reduction of this metal, of which even the most satisfactory are of a doubtful nature; hence Dr. Wollaston conceived that an account of some metallic crystals of titanium would be acceptable to the Royal Society. In the slag of the iron works of Merthyr Tydvil, there are minute cubes, which, from being imbedded in and possessing the colour and lustre of iron pyrites, have been considered to be that substance. They are not, however, like the striated cubes of pyrites, which often pass into the pentagonal dodecahedron; but have indented squares on their faces, like the cubes of com-

mon salt. An angle of one of them scratched not only a plate of steel, and ground-glass, but even plates of polished agate and rock-crystal. They were not affected by the nitric, muriatic, nitro-muriatic, or sulphuric acids; and were absolutely infusible before the blowpipe, by which their surfaces were slightly oxidated only, their brightness being restored by borax; that salt, however, did not act in any degree upon the metal, either alone, or with the addition of carbonate of soda. By nitre, they are oxidated, and they become purple or blue according to the degree of oxidation, or to the depth to which it penetrates. In this process, heat is evolved, but no proper detonation takes place. By nitre and borax in conjunction, they may be completely dissolved before the blowpipe, the former oxidating the metal, and the latter dissolving the oxide; but as these salts do not fuse together, the process is expedited by the addition of carbonate of soda. The oxide thus obtained is soluble in muriatic acid, from which it is precipitated white by alkalies and their carbonates; the solution yields by evaporation a soluble muriate. When this is dissolved, it yields with tincture of galls the well-known gallate of titanium, exactly like that precipitated from a solution of the oxide prepared from anatase. Triple prussiate of potash produces a precipitate so nearly resembling the gallate in colour, that in a number of trials, no constant difference between them could be detected. The crystals are titanium absolutely pure: though found in the vicinity of metallic iron, they contain none of that metal, nor do they contain silica, for which the oxide of titanium has a strong affinity. It was impossible to ascertain the specific gravity of crystals not more than 1-40th of an inch square; but Dr. Wollaston endeavoured to ascertain whether or not they would float in melted tin, and attempted to tin their surfaces for that purpose; but they refused to unite with that metal, nor would they combine with iron, silver, or copper. Their lustre nearly proves their metallic nature; but this is completely demonstrated by their perfectly conducting very feeble electricity. If a small slip of zinc, in contact with one of copper, be immersed in dilute sulphuric acid, bubbles of gas will rise from both metals; but if a nonconducting slip of paper be interposed, the bubbles cease to be given off by the copper. Now a small hole being made in the paper, and a cube of the titanium inserted, the communication was made perfect, and bubbles of gas were given off from both metals. This interesting paper was concluded by the remark, that the infusibility of these cubes of titanium evinced, that they were not formed from a state of metallic fusion, but by successive increments from the reduction of the oxide in the slag; in which manner we must likewise explain the formation in nature of many metallic crystals.

On the Difference of Structure between the Human Mem-

brana Tympani, and that of the Elephant; by Sir E. Home, Bart. VPRS.

In 1799, Sir Everard discovered the muscular structure of the membrana tympani in the elephant, and this discovery had led to that of the same membrane in the human ear being also muscular. He had likewise inferred that its oval shape in the elephant was the reason why the ears of that animal were not affected by musical sounds equally with those of man, in which the membrana tympani is circular; the muscular radii being of equal length in the latter case, and unequal in the former one. Since that period, he had laid all his friends in India under contribution for the head of a young elephant preserved in spirits; but remained unsuccessful until lately, when he received from Sir T. S. Raffles, to whom the natural history of the east is so much indebted, the head of an elephant only three weeks old. In this, the membrana tympani was in its proper place, and measured an inch and a half by an inch and one-eighth; the radii were attached to the point and to the two sides of the handle of the malleus, which was situated in a transverse direction. Having been informed by Mr. Corse that the elephant can hear very low sounds with great distinctness, the author attributes this faculty to the long radii of the membrane. Mr. Broadwood having sent one of his tuners with a piano to the elephant at Exeter 'Change, it was found that the animal scarcely attended to the high sounds, but listened to the low ones with apparent satisfaction. Some observations on the membrana tympani of various other quadrupeds were likewise given in this paper. It was found that the lion in the above menagerie was little affected with high musical sounds, but became quite infuriated by low ones; uttering loud yells, which ceased with the music.

LINNEAN SOCIETY.

The meetings of this Society were resumed on Nov. 5, when the reading of a paper was commenced, entitled, "Remarks on the Identity of certain general Laws which have been lately observed to regulate the natural Distribution of Insects and Fungi:" by William Sharpe Mac Leay, Esq.

Of this extended and profound paper, which was not concluded until the third meeting, on Dec. 3, we can give but a brief notice. It related to what may be termed the metaphysics of natural history. In the Horæ Entomologicæ, a work not long since published by Mr. Mac Leay, and with which our zoological readers are doubtless acquainted, he has advanced views respecting the natural series of animated beings, which, though founded on a close attention to their entire structure, may have appeared extraordinary as well as novel: they relate to a particular quinary distribution which he has observed of the subjects of the animal kingdom; and in this paper a very remarkable con-

firmation of them is announced and explained. M. Fries, in his Systema Mycologicum, published last year, observes laws of the same kind to obtain in the natural arrangement of fungi, which Mr. Mac Leay had pointed out as existing in the animal kingdom, and as probably extending to all organized beings. In the course of the paper, the difference between *affinity* and *analogy* was philosophically examined and defined. Some observations were also made on the law of continuity as far as it regards organized nature; in these was shown the distinction between *saltus* and *hiatus*, which have usually been confounded even by the first metaphysical writers. It was remarked that no *saltus* ever existed in nature, and that where there were *hiatûs*, they had arisen from the extinction of species. Towards the conclusion, it was stated, that M. Decandolle had likewise observed the general laws of natural arrangement which formed the subjects of the paper; so that these laws had thus been presented to three individuals, in different countries, nearly at the same period of time.

Dec. 3.—A Description of some Insects which appear to exemplify Mr. W. S. Mac Leay's Doctrine of Affinity and Analogy; by the Rev. W. Kirby, FRS. and FLS. was commenced.

Dec. 17.—Mr. Kirby's paper was concluded, and another by the same entomologist, entitled, "Some Account of a new Species of Eulophus (Geoffroi)," having also been read,

The Society adjourned to Jan. 21, 1823.

GEOLOGICAL SOCIETY.

Nov. 1.—A letter was read from W. C. Trevelyan, Esq. MGS. addressed to Prof. Buckland, VPGS. on the Geology of the Ferroe Islands, dated Copenhagen, Dec. 3, 1821.

Mr. Trevelyan observes, that the Ferroe Islands appear to be of the same formation as that of Antrim and of the Western Islands; they are literally mountains surrounded by water, and are composed of numerous alternations of almost all the varieties of trap, which are so regular, that the hills appear as if they were divided into a number of terraces: most of the beds are divided from each other by others (generally thin), of a red colour (sometimes green), perhaps the clay ironstone of Werner. These beds Mr. Trevelyan thinks have not been remarked in other formations; neither a curious *lava-like* appearance, which is very frequent, and the alternations extend to the height of about 3000 feet, and in some parts, perpendicular sections may be seen of more than 2000 feet high. The rocks on decomposing are seen to be stratified; the strata display surfaces generally even, but sometimes waved. Excepting in the island of Myggeneas, the dip appears to be the same throughout. In that island are some thin veins of coal. In Suderoe, a coal similar to the Scotch, but superior, occurs in abundance; the best sections of this are near Frodboe, where it is seen between

two thick beds of a hard greyish clay, which crumbles on exposure to the air, and which contains sometimes numerous nodules of a rich ironstone (carbonate of iron). The coal in Suderoe is seen rising from the level of the sea through an extensive tract of country (which the author describes), until it reaches an elevation of above 1000 feet. Basaltic veins of various descriptions are very frequent; sometimes they *alter*, but seldom *disturb*, the strata they pass through; they are frequently accompanied by thick veins of zeolite, in a state exactly resembling the steatite of Cornwall. The coal, however, at Toidnenœs is disturbed by insinuated masses of basalt. Slips are not frequent in Ferroe, but a remarkable one is described in Soinoe, cavities of great length, perfectly circular, extending in a direct line, and incrusted with zeolite, are common; one was seen, of which the one side was filled with compact zeolite; the other with clay ironstone. Conglomerates are common; one only was observed of *rolled* pebbles, apparently of the rocks of the island. In two of the islands, a bed of greenstone, in some parts columnar, is seen of great extent: it is 100 feet in thickness.

Native copper is very frequent, but not abundant, in most of the rocks. At Famarasund, in Suderoe, it occurs in clay ironstone, in thin plates; in the other rocks, it is generally crystallized, frequently inclosed in zeolite. Specimens of most of the zeolite family were procured, and a variety of tabular calc spar, first found in Ferroe by Sir G. Mackenzie, and unknown elsewhere.

On his return, Mr. Trevelyan, in passing from Fludstrand, in Jutland, to Copenhagen, crossed a considerable extent of chalk; the whole of the country is covered with large rolled blocks of various primitive rocks.

Near Fludstrand are some beds of sand, clay, and marl, apparently above the chalk.

The letter concludes with observations on the aurora borealis, and with reasons tending to confirm the opinion that Ferroe is the Thule of the ancients.

ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

Ninth Annual Report of the Council.—The progress of the institution since the last anniversary, if not equal to the wishes of its friends, is at least encouraging; though the Society had to regret the loss of their late able Secretary, Dr. Forbes, whose professional pursuits occasioned his removing from this county; and the Council considered it due to the zeal and ability displayed by that gentleman, to elect him an Honorary Member.

The cabinets have been enriched by many valuable donations; and in particular by a splendid series of minerals from Mount Vesuvius, for which the Society is indebted to the kindness of their illustrious townsman, Sir Humphry Davy. The value of this accession to the Museum is not a little enhanced by the

circumstance of the package having been missing for several years owing to the disturbances which occurred at Naples, so that it was given up as lost, when it happily reached its original destination.

The collection of specimens in most of the departments of mineralogy is now become interesting, and being open to public inspection, creates a growing attention to the subject, and has led to the discovery of minerals hitherto unknown in this county, and is thus accomplishing one important object of the institution. The series of our native metallic minerals has also been augmented both by purchase and donation: but while the Council gladly report its continued progress, they beg to remind the members that this department of the cabinet is at once the most interesting and hitherto most defective; and recommend it earnestly to the attention of its friends, particularly to those whose connection with the mines afford opportunities of procuring rare specimens.

The library and funds have also been increased, the latter by a liberal donation from John Hawkins, Esq. to whose interesting communications and encouragement, the institution has been from its commencement so greatly indebted.

Flattering invitations to correspondence have been received in the course of the past year from foreign institutions and men of science, which shows that this Society has already attracted notice, and is contemplated with interest both at home and abroad.

The Council have also the pleasure to congratulate the Society on the publication of the second volume of its Transactions, as ordered by the last general meeting, and they flatter themselves that it will not be found unworthy of its predecessor. It was judged proper to confine its contents entirely to papers relative to the geology and mineralogy of Cornwall; although it occasioned the regret of thereby omitting many valuable communications. A large space will be found devoted to the detail of numerous facts and experiments on the much controverted subject, the Temperature of Mines, and also on the Phenomena of Veins, which cannot fail to attract much attention and further investigation. To the authors and editors, the Society will feel much obligation, particularly to Mr. Carne, not only for so large a portion of the work itself, but also for his indefatigable attention to the arrangement of the papers and superintendence of the press. There are likewise two other circumstances deserving of notice;—that the volume was printed in this town (Penzance), and that the plates were engraved by a self-taught native artist; and the execution of both reflects no small credit on the parties.

Since the last anniversary, a course of lectures on the elements of chemistry has been delivered by the Secretary, Dr. Boase, to a numerous and attentive auditory, and received with much applause and merited approbation. And the Council have also

the pleasure to report, that there is evidently a growing attention to scientific pursuits, which encourages them to cherish and repeat the expression of their anxious hope that the period is not distant, when the great and leading object of this Society will be realised, and Cornwall at once distinguished and enriched by the establishment of a School of Mines.

By order, HENRY S. BOASE, *Sec.*

The following papers have been read since the last report:

On the Tin Ore of Botallack and Levant. By Henry S. Boase, MD. Secretary of the Society.

A further Account of the Mineralogy and Geology of St. Just. By Joseph Carne, Esq. FRS. MRIA. Member of the Society.

On the Serpentine District of Cornwall. By the Rev. Canon Rogers, Member of the Society.

On the Neptunian Theory of the Formation of Veins. By Henry Boase, Esq. Treasurer of the Society.

On the Noxious Gases of Mines. By Dr. Boase.

On Submarine Mines. By Joseph Carne, Esq. FRS. &c.

On the Temperature of the Cornish Mines. By M. P. Moyle, Esq. Member of the Society.

A proposed new Method of Drawing Mining Maps and Sections. Communicated by Mr. Fox.

On the Temperature of Mines. By Robert W. Fox, Esq. Member of the Society.

On the Utility of a School of Mines. By Dr. Boase.

An Account of the Quantity of Tin produced in Cornwall in the Year ending with the Midsummer Quarter, 1822. By Joseph Carne, Esq. FRS. &c.

An Account of the Produce of the Copper Mines of Cornwall, in Ore, Copper, and Money, in the Year ending the 30th June, 1822. By Mr. Alfred Jenkyns.

Officers and Council for the present Year.

President.—Davies Gilbert, Esq. MP. VPRS. &c. &c.

Vice-Presidents.—William Rashleigh, Esq. Charles Lemon, Esq. John Scobell, Esq. John Paynter, Esq.

Secretary.—Henry S. Boase, MD.

Treasurer.—Henry Boase, Esq.

Librarian.—T. Barham, MD.

Curator.—Edward C. Giddy, Esq.

Assistant-Secretary.—R. Moyle, Jun. Esq.

The Council.—T. Bolitho, Esq.; Joseph Carne, Esq.; Stephen Davy, Esq.; Alfred Fox, Esq.; G. D. John, Esq.; Rev. C. V. Le Grice; M. P. Moyle, Esq.; Rev. Canon Rogers; H. P. Tremenheere, Esq.; John Williams, Jun. Esq.

Article XI.

SCIENTIFIC INTELLIGENCE, AND NOTICES OF SUBJECTS CONNECTED WITH SCIENCE.

I. *On the Temperature produced by the Condensation of Vapour.*

Mr. Faraday, in some observations published in the Annales de Chimie, xx. 329, has illustrated a curious property of vapour which, as he remarks, though it might have been deduced from known facts, had never been cited or confirmed by experiment. It seems, indeed, that the property had been known in Paris to some of the chemists, but that it had never been published.

Hold a thermometer horizontally so that its bulb may be introduced into a current of vapour as it issues from a boiler or tea-kettle: it will soon indicate 212°; then drop on to it a little powdered nitre, and immediately the temperature will rise to 230° or higher. This effect is due to the condensing power excited by the salt on the vapour, which, reducing the latter to the fluid form, liberates the heat that raises the thermometer.

In making the experiment, care should be taken that the water condensed on the stem of the instrument does not run down and dilute the salt, for then the temperature falls. Another method of operating is to tie up the salt or substance, round the bulb of the thermometer in a bit of lint or flannel, and introduce it so covered into the steam. The following are temperatures obtained by the use of different substances; the first column of numbers as given by the last process, and the second by the other:

Sulphate of magnesia	214	218
*Tartrate of potash	230	236
*Tartaric acid	221	226
Sugar	223	216
*Muriate of ammonia	227	230
*Citric acid	228	230
*Nitre	230	232
Nitrate of magnesia	236	236
Nitrate of ammonia	240	236
Acetate of potash	258	244
Subcarbonate of potash	262	258
Potash	—	300 and upwards.

Those marked * are convenient for the experiment with the naked bulb.

The effect, as might be expected, continues at different pressures, and the same difference of temperature which exists between a clean thermometer and one coated with a salt when placed in steam at 212° under atmospheric pressure, holds when the pressure and temperature are raised.

Mr. Faraday had stated that at the same pressure a boiling aqueous saline solution gave off steam of the same temperature as boiling water. M. Gay-Lussac makes some remarks on this statement, and shows, that

with the saline solution, the temperature of the vapour is the same as that of the solution itself. We understand that Mr. F. has verified M. Gay-Lussac's statement by experiment, and satisfied himself of its accuracy.

II. *Index to Kirby and Spence's Entomology.*

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Dec.* 22, 1822.

I beg to submit, through your journal, to the learned authors of the Introduction to Entomology how important an addition to each of their delightful volumes a pretty copious index would be; and how imperfect their work is without it. It is of course intended that the last volume should comprise all that is necessary in this way; but this is not enough, for during the many years that intervene between the appearance of the first and the last volume, the entomological student is deprived of all the advantages of reference, unless he make an index for himself. All the leading facts of the two first volumes may be very readily embraced in one index; and I would suggest to Messrs. Kirby and Spence, that it would be desirable to furnish this assistance to the public without delay, as well as to provide every future volume with an index for itself, with the exception of the last, which will necessarily contain general references for the whole work.

I remain, dear Sir, yours sincerely,

NORFOLCIENSIS.

III. *Separation of Plumbago from Cast-Iron.*

A curious paper on this subject has appeared in No. 14 of the Edinburgh Philosophical Journal; the facts related in which we shall proceed to state, and afterwards to offer a few remarks on the theory which has been deduced from them by the writer of the paper, Dr. Mac Culloch.

In the frequent examination of the metal of the iron guns delivered by the contractors to the ordnance, by solution, according to Bergman's suggestion, Dr. M. found that the quantity of plumbago in the metal bore no relation to its strength or goodness, but that the results were sometimes curious, from the very variable quantity which different specimens of the iron contained. The trials were far from confirming the opinion that the worst or weakest metal contained most plumbago; and on one occasion, an exceedingly tough specimen was found to contain a most unusual proportion of this substance, and that in a disengaged state, being visible on breaking the metal; which appeared as if it had been rubbed with powdered black-lead, and left its trace on paper. Where the plumbago was most abundant, the colour of the fracture of the iron was most grey; and Dr. M.'s trials go to prove, in contradiction to the opinion of many iron-founders, that the greyest metal is the toughest. The plumbago was always obtained in the state of powder, and in very small proportion when compared to that obtained from pig-iron.

The same experiments were repeated on the pig-metal used for shells, which is generally distinguished into three kinds; white, grey, and black. All these afforded very large proportions of plumbago, but various in different specimens; the black metal seemed to afford the greatest quantity, but that which was most brilliant and silvery also

yielded it in abundance. In 1807 or 1808, Dr. Mac Culloch was requested to go to a London porter brewery to see an appearance which had very much surprised the people employed in it. They had taken some iron out of their porter backs in making repairs, and had found it, as they said, red-hot. This was found to be an exaggeration; but on removing the iron articles from the porter, they became so hot on scraping off the surface, that it was disagreeable to handle them; while they smoked from the evaporation of the moisture: they were cast cones, perforated with holes, and about an inch thick, used as strainers to prevent foreign substances from getting into the pipes, and had been immersed in the porter for many years. On examination, some of them were found to be entirely plumbago; while in others there was a thick coat of that substance on each side, a little iron only remaining in the middle.

Shortly afterwards, Dr. M. met with the following relation in one of his journeys in the Western Isles. In 1740 an attempt was made to weigh one of the Spanish Armada, which had foundered off the coast of Mull; this proved unsuccessful, but some brass and iron guns were brought up, the former bearing the date 1584. The iron guns were deeply corroded; and on scraping them, it was said that they were found so hot that they could not be touched, and that they did not become cool till they had been two or or three hours exposed to the air.

The following are the general results of Dr. Mac Culloch's experiments on this subject: The blackest pig-metal appears to yield the greatest quantity of plumbago, and in the most solid state. When the experiment is complete, the produce equals the iron in bulk, and is a solid mass capable of being cut by a knife, even into pencils; but as far as has been observed, it is of a much more coarse grain, or scaly granular texture, than natural black-lead. To procure it in perfection, the acid should be very weak, and the operation is then necessarily very tedious. Acetic acid appears to be the best, and it is by this that it is produced in porter-backs in the waste-pipes of breweries, and in calico-printing-houses, where sour paste is employed. If the experiment be perfect, the plumbago becomes hot on exposure to the air, smoking while there is any moisture to be evaporated, particularly when the surfaces are scraped off in succession; there is no apparent difference in the plumbago before and after this operation. When the substance does not heat, on being taken out of the fluid, the whole process of oxygenation appears to have taken place in the solution, probably from an excess of strength in the acid.

From these facts, Dr. Mac Culloch draws the following inferences: that plumbago, by which name he designates the carbon, as it exists in cast-iron, is a *metal*, and black-lead its *oxide:* that in white-pig, probably, the combination is this metal and iron; and that in the black it exists in a state of approximation to black-lead: that the operation of the acid is to dissolve the iron, and to oxygenate the plumbago so as to convert it into black-lead: and that if the acid be strong, the whole operation is completed in the solvent; otherwise some additional oxygen is required to produce it in a state of permanence in the air, and that the absorption of this generates the heat in the experiment: lastly, that the metallic nature of the base of charcoal is also proved from these facts. And lest this reasoning should be deemed unsatisfactory, Dr. M. adds the following argument: " The specific gravity

of pig-iron is about 7·6, and that of black-lead is 2, or less. Now the bulk of black-lead procured in the experiment is equal to that of the original iron exposed to solution. Two such bodies could not co-exist in the same space, or, if that could be imagined, the specific gravity of such iron must be far more different from that of pure iron than it is. If pure iron indeed is freed from the effects of condensation by heating, it scarcely differs in specific gravity from pig-metal. Thus while we conclude that the plumbago combined with the iron is a metal, we may also infer that the specific gravity of that metal is not very different from that of iron."

Upon this theory we trust that Dr. Mac Culloch will excuse our offering the following remarks: In the first place, nothing but carbon has been detected in the diamond by the most refined and delicate investigations of chemistry, those of Sir H. Davy, Messrs. Allen and Pepys, and others: that gem, therefore, must be a form of Dr. M.'s new metal; now if black-lead be its oxide, supposing it to contain only one atom of oxygen, then, when equal weights of each substance are burnt in oxygen gas, the former should require, for its complete conversion into carbonic acid, *twice as much oxygen as the latter;* but the experiments of Messrs. Allen and Pepys have demonstrated, that both these substances require for their combustion *precisely the same volume of oxygen.*

Secondly, Dr. Mac Culloch does not seem to be aware of the existence of *silicium* in cast-iron. The experiments of Mr. Daniell, recorded in vol. ii. of the Journal of Science, show that the absorption of oxygen, and the consequent evolution of heat, by the black-lead separated from the metal, is owing to the conversion of *silicium* into *silica*, and not to that of any unknown principle into black-lead.

We are not sure that we understand the concluding argument, but does it not indicate, either that Dr. Mac Culloch considers cast-iron to be a mechanical mixture of carbon and the metal, or that he thinks, (which is likewise contrary to the known fact), that the arithmetical mean of the specific gravities of the ingredients of a compound is the true specific gravity of the compound itself?

Article XII.

NEW SCIENTIFIC BOOKS

PREPARING FOR PUBLICATION.

A Narrative of a Voyage round the World in the Uranie, Capt. Freycinet, dispatched on a Scientific Expedition by the French Government during the Years 1817, 1818, 1819, and 1820; in a Series of Letters to a Friend. By J. Arago, Draftsman to the Expedition. The Work will form a Quarto Volume, embellished with 26 Engravings.

A Description of an Antediluvian Den of Hyænas, discovered at Kirkdale, in Yorkshire, in 1821, and containing the Remains of the Hyæna, Tiger, Bear, Elephant, Rhinoceros, Hippopotamus, and 16 other Animals, all formerly Natives in this Country. With a Compa-

tative View of many similar Caverns and Dens in England and Germany; and a Summary Account of the Evidence of diluvian Action afforded by the Forms of Hills and Valleys, and the general Dispersion of Beds of Gravel and Loam, containing similar Bones, over great Part of the Northern Hemisphere. By the Rev. W. Buckland, FRS. FLS. and Professor of Mineralogy and Geology in the University of Oxford. Illustrated by a Map, Views, and Sections of the Caves and Drawings of the Animal Remains.

A Treatise on Navigation and Nautical Astronomy, adapted to Practice and the Purposes of Elementary Instruction. By Mr. Reddle, of the Royal Naval Asylum.

JUST PUBLISHED.

Illustrations of the Inquiry respecting Tuberculous Diseases. By John Baron, MD. Physician to the General Infirmary at Gloucester. With coloured Plates. 8vo. 15*s*.

Lectures on the Structure and Physiology of the Male Urinary and Genital Organs of the Human Body, and on the Nature and Treatment of their Diseases, delivered before the Royal College of Surgeons. By the late James Wilson, FRS &c. 14*s*.

Journal of an Horticultural Tour through Flanders, Holland, and the North of France. By a Deputation of the Caledonian Horticultural Society, consisting of Mr. Neill, Secretary; Mr. Hay, Planner; and Mr. Macdonald, Chief Gardener at Dalkeith Park. With Plates. 8vo. 16*s*.

A new View of the Infection of Scarlet Fever, illustrated by Remarks on other contagious Disorders. By W. Carmichael, MD. FRS. Fellow of the College of Physicians, &c. 8vo. 5*s*.

Article XIII.

NEW PATENTS.

J. Witcher, Helmet-row, Old-street, mechanic, M. Pickford, Wood-street, carrier, and J. Whitbourn, Goswell-street, coachsmith, for an improvement in the construction of wheels.—Sept. 27.

S. Pratt, bond-street, trunk-manufacturer, for improved straps and bands for the better securing of luggage.—Sept. 27.

T. Binns and J. Binns, Tottenham-court-road, engineers, for improvements in propelling vessels, and in the construction of steam-engines. —Oct. 18.

W. Jones, Bodwellty, Monmouthshire, engineer, for improvement in the manufacturing of iron.—Oct. 18.

S. Wilson, Streatham, Esq. for a new manufacture of worsted.—Oct. 18.

U. Lane, jun. Lamb's Conduit-street, straw-hat manufacturer, for an improvement in the platting of straw, and in manufacturing bonnets, &c. therefrom.—Oct. 18.

J. Williams, Cornhill, stationer, for a method to prevent the frequent removal of the pavement and carriage-path, and for laying down and taking up pipes, &c.—Oct. 18.

Article XIV.

METEOROLOGICAL TABLE.

1822.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.	Daniell's hyg. at noon.
11th Mon.								
Nov. 1	S W	29·97	29·81	61	55	—	—	
2	S W	30·10	29·81	62	48	—	10	
3	S W	30·36	30·10	58	38	—		
4	W	30·36	30·34	53	40	—		
5	W	30·34	30·29	55	46	—		
6	S W	30·29	30·05	55	40	—		
7	S W	30·05	30·03	58	38	—	—	
8	N	30·07	30·03	52	28	—	—	
9	N E	30·07	29·85	53	39	—	29	
10	N E	30·35	29·87	52	40	—		
11	N E	30·35	30·19	50	40	—		
12	S	30·19	30·01	56	42	—	09	
13	N W	30·01	29·55	50	33	—	18	
14	N W	29·61	29·35	51	40	—	32	
15	S W	29·43	29·35	51	41	—	58	
16	N E	29·71	29·40	44	32	97	62	
17	S W	29·72	29·71	51	45	—	05	
18	S W	29·95	29·72	55	42	—		
19	S W	29·90	29·78	56	41	—	36	
20	Var.	29·78	29·75	56	49	—	13	
21	W	29·98	29·78	51	40	—		
22	S W	29·98	29·74	52	45	—	30	
23	S W	29·99	29·74	52	43	—		
24	S W	29·92	29·70	53	45	—	07	
25	S W	29·70	29·68	52	45	—	04	
26	S W	29·70	29·68	55	45	—	—	
27	S W	29·74	29·60	50	36	—	05	
28	Var.	29·68	29·46	45	36	—	15	
29	S W	29·58	29·50	46	31	—	08	
30	S W	29·50	29·50	47	34	91	05	
		30·36	29·35	62	28	1·88	3·46	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Eleventh Month.—1. Fine. 2. Cloudy. 3. Fine. 4, 5. Cloudy and fine. 6—8. Fine. 9. Foggy. 10. Cloudy. 11. Morning, foggy. 12. Rain at night: day, fine. 13, 14. Cloudy. 15. Morning, fine: night, rainy. 16. Rainy. 17. Cloudy and fine. 18. Cloudy. 19. Cloudy: night rainy. 20. Cloudy. 21. Fine. 22. Cloudy. 23. Cloudy and fine. 24. Fine. 25. Fine. 26. Cloudy. 27. Cloudy and fine. 28. Rainy. 29. Showers. 30. Showers: overcast.

RESULTS.

Winds: N, 1; NE, 4; S, 1; SW, 17; W, 3; NW, 2; Var. 2.

Barometer: Mean height

For the month.. 29·860 inches.

For the lunar period, ending the 6th .... 29·860

For 13 days, ending the 8th (moon north).......................... 30·048

For 14 days, ending the 22d (moon south).......................... 29·824

Thermometer: Mean height

For the month.. 46·650°

For the lunar period... 50·616

For 31 days, the sun in Scorpio.................................... 50·000

Evaporation.. 1·88 in.

Rain... 3·46

Laboratory, Stratford, Twelfth Month, 21, 1822. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

FEBRUARY, 1823.

Article I.

Experiments and Observations on Indigo, and on certain Substances which are produced from it by Means of Sulphuric Acid. By Mr. Walter Crum.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Glasgow, Jan.* 1, 1823.

Indigo may be obtained in a state of tolerable purity by the ordinary process of agitating the yellow liquid, which forms the dyer's blue vat, with common air, till the deoxidized indigo which is there held in solution by lime-water is revived; and then digesting the precipitate in dilute muriatic acid, to remove a little iron, and carbonate of lime, which it contains. In this state, it is known by the name of *precipitated indigo,* and must be distinguished from the powder so called by Bergman, a substance to which I shall refer more particularly in the sequel. It generally contains a small portion of sulphate of lime, and, as Dr. Thomson observed, a little resin, which is removable by alcohol.

It has been long known, that when indigo is heated, it sublimes. The first mention of this fact that I have noticed is contained in a work on calico printing, published in 1789 by O'Brien, a pattern drawer in London, who also gives a method for collecting the sublimate. "The curious may sublime indigo, and thereby procure flowers, as with zinc, sulphur, &c. For experiments on a small scale, it may be done in a common flask

over a common fire, defending the flask from the contact of the fire."

To prepare these flowers, Chevreul directs* that eight grains of common indigo in powder, in a covered crucible, should be placed upon burning coals; in which case the colouring matter will crystallize in the middle part of the crucible, from which it is to be detached with a feather when cold. I have never been able to obtain any quantity of it in this way; part of it is always discoloured, and the whole of it is condensed upon the ashes, which are in the state of a fine powder, and from which it cannot be detached without contamination.

I succeeded, however, by another method to procure as much as I needed for my experiments, perfectly pure. I used the covers of two platina crucibles, nearly three inches in diameter, of such a form, that, when placed with their concave sides inwards, they were about three-eighths of an inch distant in the middle. I placed thinly about the centre of the lower one ten grains of precipitated indigo, not in powder, but in small lumps of about a grain in weight; then, having put on the cover, I applied the flame of a spirit-lamp beneath the indigo. In a short time, this substance partially decomposed, begins to melt, and the purple vapour to be disengaged, which is known by the hissing noise that accompanies it. The heat is continued till this noise nearly ceases, when the lamp is withdrawn, and the apparatus allowed to cool. Then, on removing the cover, the sublimed indigo will be found planted upon its inner surface, with sometimes a few long needles upon the bottom of the apparatus, which are easily removed from the button of coaly matter that remains. In this way I have generally obtained 18 to 20 per cent. of the indigo employed; a small quantity unavoidably escapes, but I am persuaded that very little more can, by any means of this kind, be obtained. I have made several attempts, by using different forms of apparatus, to prepare this substance on a greater scale; but have found none that answers so well as that which I have described. When the cover is kept cool, as by means of a wet cloth, none of the indigo condenses upon it. The interior of the apparatus being then comparatively cold, the vapour is condensed before it reaches the cover, falling back, or rather crystallizing upon the cinder. The same effect is produced when ashes are formed instead of a fused coal; and pure indigo when pounded, and common indigo in any shape, always leave a quantity of loose matter.

Those who cannot readily procure precipitated indigo for the purpose of subliming, may find it convenient to combine with my method, one lately given in the Journal de Pharmacie, by MM. Le Royer and Dumas. It consists in spreading about 30 grains of common indigo in coarse powder upon an open silver capsule,

* Annales de Chimie, tom. lxvi. April, 1808.

and applying the heat of a spirit-lamp till all the sublimed indigo is formed upon the surface of the ashes. On repeating this process, I find that ten parts of common indigo yield one of sublimed indigo, which is, however, far from being pure. By resublimation in my apparatus, it is again reduced one-half from the loss of its impurities, and some vapour.

I shall here describe what else takes place during the sublimation. Ten grains of precipitated indigo in the apparatus I have described yielded

1·88	grain of sublimed indigo.
6·44	grains of cinder remained, and consequently
1·68	grain of volatile matter escaped.
10·00	

Thirteen grains of the same indigo, kept a quarter of an hour at a strong red heat in a small platina crucible, firmly, though not exactly closed, left 7·9 grains of cinder, which is equal to 61 per cent.

In order to ascertain what gases were evolved during this destruction of the indigo, I introduced 5·28 grains into a small glass tube connected with a mercurial trough. On applying the heat of a spirit-lamp, the vapour of indigo was formed, and condensed in the colder part of the tube, but was at last destroyed by repeated applications of heat. A quantity of water appeared in the tube, and 0·96 cubic inch of gas was found in the receiver. On removing the tube, it was found to have lost in weight 0·71 grain, or 13·5 per cent. of the indigo employed. The water that was formed had a disagreeable burnt ammoniacal smell. I found, on analyzing the gas in the receiver (making allowance for the common air of the apparatus, and a small portion of gas remaining in the tube), that it consisted for 100 of indigo of

Carbonic acid	2·8
Carburetted hydrogen and carbonic oxide	0·8
Azote	1·9
The difference between the sum of these and the loss 13·5 was water, with a little ammonia.	8·0
	13·5

Sublimed Indigo.

Indigo sublimes in long flat needles, which readily split when they are bruised into four-sided prisms.

Viewed at a particular angle, they have the most brilliant and intense copper colour; but when lying in heaps, they have a rich chesnut-brown colour; one that would be produced by mixing a very little yellow with a bright but deep reddish purple.

Besides these needles, this substance is found in the form of

plates, much broader than the needles, and extremely thin; twisted sometimes almost into tubes. These appear to the naked eye perfectly opaque. I was not a little pleased, however, with their unexpected appearance, when seen through the microscope. Viewed obliquely, they appear still opaque, and copper coloured like the needles; but when held perpendicularly to the rays of light, they are seen to be transparent, and of a beautiful blue colour, exactly similar to a dilute solution of indigo which has been acted upon by sulphuric acid. Their intensity varies, according to the thickness of the plate, from a blue just distinguishable from white, to one almost black. The bronze colour which these crystals assume when in heaps is obviously a mixture of the copper colour with this blue.

The vapour of indigo is transparent, and of a most beautiful reddish-violet colour, resembling a good deal the vapour of iodine, but sufficiently distinguished from it by the shade of red. The sublimation takes place at the heat of about 550° Fahrenheit; for the vapour rises at a heat lower than that of melting lead, and requires more than the melting heat of bismuth. Upon the rough bright surface of the lead, I observed some of the crystals melt while the vapour was rising; but I have in no other circumstances remarked any thing like fusion, till the substance was decomposed. Hence the melting point of indigo, its point of volatilization, and that at which it is decomposed, are remarkably near each other.

The specific gravity of sublimed indigo is 1·35.

These crystals sublime when heated in open vessels, leaving no residue. In close vessels, the vapour is at first reddish-violet, as in the open air; but as the heat advances, it acquires a tinge of scarlet; and before it is entirely decomposed, becomes deep scarlet, and then orange coloured: a quantity of charcoal is at the same time deposited.

Action of Oils.—Of the essential oils, oil of turpentine dissolves at its boiling heat as much indigo as gives it the fine violet colour of the vapour of indigo, but a slight reduction of temperature is sufficient to precipitate the whole of it. The fixed oils and fatty substances, as they may be heated to a higher degree, exert a more powerful action upon indigo. None of them that I have tried act upon it at the heat of boiling water; but when the heat is increased, they gradually dissolve it, acquiring the colour of its vapour much more deep than oil of turpentine does. If the solution be cooled at this period, the indigo precipitates blue. As the heat is continued, more of the indigo is dissolved, but the colour of the solution begins to change; it gradually inclines to crimson, and has then begun to be destroyed. It is now green when cooled. Heated still more, the solution is of a strong crimson; then becomes orange; and at last, when entirely decomposed, it is yellow, which colour it retains when cold.

Determination of the Ultimate Constituents of Indigo.

The apparatus which I employ for the analysis of indigo with peroxide of copper, is simply a tube of green glass, seven inches long, and three-eighths of an inch wide, shut at one end, and connected with a mercurial trough by means of a small bent tube, joined to the other by a tube of caoutchouc firmly tied.

The indigo is first ground with a quantity of peroxide of copper, and when that is introduced into the tube, another portion of peroxide is put over it, and then some metallic copper thrown down from its sulphate by a plate of zinc, and ignited in a close vessel. Lastly, I fill up the remaining space (about a couple of inches) with a piece of glass tube, shut at both ends, which nearly fits the other. This keeps the materials in their place, and reduces as much as possible the quantity of common air in the apparatus. The tube is then heated with three spirit-lamps, of which two keep the metallic copper and the pure peroxide at a red heat; while the third traverses gradually that part of the tube which contains the indigo.

When I began these experiments, I took the usual precaution of heating the peroxide of copper to redness immediately before I made use of it. I soon found, however, that before I could get the vegetable matter ground with it, and introduced into the tube, it had attracted a quantity of water from the air, which varied according to the hygrometric state of the atmosphere, and of course, the length of time employed. It then occurred to me that all error from this source would be obviated, if I allowed the peroxide to be saturated with moisture, by leaving it freely exposed to the air, and at every analysis (at least when the state of the atmosphere changed), press 150 grains of it into a small platina crucible which just holds that quantity, heat it dull-red within another crucible, and ascertain its loss of weight without removing the cover.*

I have in this way made several analyses of indigo, which differed very little from each other. I choose the following one as being nearly a mean of the rest:

Analysis.—One grain of sublimed indigo was ground with 90 grains of peroxide of copper; 25 grains more were put over it in the tube; and above that, 30 grains of metallic copper. These substances contained 0·11 grain of water.

* Berzelius has pointed out the instantaneous attraction of water by the oxide of copper (Ann. de Chimie, xvii. 27), and cautioned chemists against the fallacy arising from the neglect of it; and M. de Saussure, in a note to his analysis of hog's lard (Ann. de Chimie, xi. 395), makes a general remark upon those analyses where peroxide of copper is employed. "Ses resultats" (those of M. Berard), "ainsi qu'un grand nombre de ceux obtenus par ce procédé, m'ont paru pécher par excès d'hydrogène." This excess is owing in all probability to the neglect of a small portion of water attracted by the peroxide. I have found 100 grains when newly prepared take as much as 3-10ths of a grain of water for saturation in damp weather. When it has been several times used, it does not take so much.

The tube, after the operation, had lost in weight 3·17 grains, of which 1 grain being indigo, and 0·11 grain water from the copper, 2·06 grains were oxygen supplied by the peroxide. The gas in the receiver was = 6·46 cubic inches, mean temperature and pressure. Of this, potash absorbed 5·82 cubic inches, leaving a residue of 0·64 cubic inch.

This residue consists of the common air of the apparatus, together with the azote contained in the indigo. By filling the mouth of the tube, as I did, with a round piece of glass, and using a very small conducting tube, scarcely any empty space is left in the apparatus; but the peroxide of copper, being a very loose substance, and merely shaken down into the tube, without being pressed, encloses a quantity of air, which is very considerable. This, on the idea that the quantity was trifling, has sometimes been neglected altogether; but more frequently as much of it as possible has been driven out, by heating a part of the tube, previous to the commencement of the experiment, and the remainder neglected. A very simple and obvious method of ascertaining with accuracy its amount, consists in making an analysis of any vegetable substance, as *sugar,* which contains no azote, in the same apparatus, and with the same quantity of materials. Here nothing passes into the receiver but carbonic acid, and the whole of the common air which the apparatus contained. The former, being absorbed by means of potash, leaves a quantity of common air, exactly equal to the common air in the indigo experiment; of course the difference between that, and the total residue of gas obtained from indigo, is azote. I thus found that the apparatus which I employed contained 0·26 cubic inch of common air; which, being deducted from the total residue after absorption by potash 0·64, leaves 0·38 cubic inch, or 0·1126 grain of azote, as the quantity of that substance in a grain of indigo. This method, as well as that of estimating the water in peroxide of copper, I communicated to Dr. Ure, when I mentioned to him the existence of hydrogen in indigo.

The 5·82 cubic inches carbonic acid gas + 0·08 which I found to remain in the apparatus = 5·9; and this, allowing for aqueous vapour, is $5 \cdot 9 \; \frac{29 \cdot 1 - 0 \cdot 676}{29 \cdot 1} = 5 \cdot 762$ cubic inches dry carbonic acid gas, which consist of 0·7322 grain carbon, and 1·952 grain of oxygen. But 2·06 grains of oxygen were taken from the peroxide of copper, which is 0·108 grain more than was necessary to burn the carbon. This indicates 0·0135 grain of free hydrogen.* The remainder is oxygen and hydrogen in the

* The results of two careful experiments made at different times with loaf sugar, exactly in the same manner as with the indigo, perfectly satisfied me as to the accuracy of this part of the experiment. Though the quantities of carbon were not precisely alike in these two experiments, the loss of weight sustained by the peroxide, after deducting the water it contained, was exactly equal to the respective quantities of oxygen in the carbonic acid, calculated in the same manner as in the text. In one case, I obtained

proportions which form water. Hence the composition of indigo is

Carbon	73·22
Azote	11·26
Oxygen	12·60
Hydrogen	2·92
	100·00

These numbers correspond very nearly to

1 atom of azote	1·75 or	10·77
2 atoms of oxygen	2·00	12·31
4 atoms of hydrogen	0·50	3·08
16 atoms of carbon	12·00	73·84
	16·25	100·00

The gas remaining in the apparatus at the conclusion of the experiment, was estimated by heating the same tube with an equal quantity of peroxide of copper without organic matter, and observing how much air was driven over into the receiver. The difference between this and the whole air, as found in the sugar experiment, is pretty nearly the bulk of gas remaining. The temperature of the gas when measured was 58°, and the barometric pressure 29·1 inches.

I have also made several analyses of well-dried precipitated indigo; and allowing for a minute portion of sulphate of lime which it contained, I got results which agreed perfectly with the analyses of sublimed indigo. I find too, that both these substances are acted upon in the same manner by other bodies. The different effect of heat depends obviously, upon some difference in the mechanical arrangement of their particles.

Brugnatelli has proposed to call this sublimate *indigogen*, because, when united to the fecula of the plant, it forms common indigo. But such a nomenclature is inadmissible in chemistry. Upon the same principle, potash ought to be called potassogen, because, when united to certain foreign substances, it forms crude potash. The same chemist considers this substance as a metal, because, as M. Von Mons informs us,* he found it might be amalgamated with mercury. Dobereiner repeated this experiment of Brugnatelli, and formed not only the amalgam, but

41·55 per cent. of carbon, and in the other 42·14. The means of these give the following for the composition of sugar:

	Carbon	41·8
Wate	Oxygen	51·7
	Hydrogen	6·5
		100·0

It is needless to add that the sugar was in both cases dried at 212° in a vacuum.

* *Annals of Philosophy*, vi. 75.

what is still more wonderful, by placing this amalgam in a solution of nitrate of silver, he obtained crystals in the form of an artichoke, which were an alloy of the metal of indigo with silver. In consequence of these statements, I made several attempts to amalgamate sublimed indigo, as well by the process of Dobereiner, as by others which I thought more likely to succeed, but in vain. I could in no case perceive the least alteration in the fluidity of the quicksilver.

Action of Sulphuric Acid upon Indigo.

When indigo is digested in concentrated sulphuric acid, it is well known to suffer a remarkable change, being converted into a peculiar blue substance, entirely different from indigo, with which the Saxon blue is dyed.

This substance has been so little attended to by chemists that no one has yet thought of giving it a separate name. I shall venture to propose for it that of *cerulin*, from the colour of its solution.

The mixture of the blue substance with sulphuric acid is a semifluid, which requires a considerable quantity of water to dissolve it. When potash is added to this solution, previously filtered, a deep-blue precipitate is formed. I was surprised, however, when making the experiment, to find the precipitate as plentiful before one-fourth of the acid was saturated, as when the solution was made altogether neutral. To another portion, I added potash previously saturated with sulphuric acid, and found the same precipitate formed as with potash alone.* I threw the precipitate upon a filter, and washed it with water, in order to examine whether it was the pure colouring matter that had separated. The first washing did not take away much of the precipitate; the next, however, sensibly diminished it; but with the third portion of water, it almost wholly disappeared.

In order to discover the cause of this increased solubility, I made a saturated solution of sulphate of potash in water, and, putting into it a little of the blue pulpy substance that remained upon the filter, I agitated it thoroughly. The solution remained altogether colourless. I found the same to be the case when the muriate, the acetate, or any other salt of potash, was employed. Alcohol also, and ether refused to dissolve this substance. Put into pure water, however, it immediately dissolved, forming the same deep blue solution that had passed through the filter.

* That the solution of indigo in sulphuric acid is precipitated by neutral salts is not a new fact. Berthollet (Art of Dyeing, ii. 50) says, that the "fixed alkalies saturated with carbonic acid," as well as "alcohol, saturated solutions of alum, sulphate of soda, or other salts containing sulphuric acid," form precipitates in this solution. My experiments show, I think, that the effect does not depend upon the presence of sulphuric acid in the precipitant; that some sulphates have no such effect; and that alcohol does not precipitate the original solution at all.

It seemed then only necessary to dissolve in water some salt of potash, to enable it to wash this substance without dissolving it. I found the acetate to answer extremely well, and this salt possesses the advantage over the muriate or sulphate of not being precipitated by alcohol from a weak solution in water, as they are. It may consequently be afterwards removed by washings with alcohol.

Such edulcorations with acetate of potash, I repeated so often upon a quantity of precipitate, taking it every time off the filter, and agitating it well in a phial with the liquid, that not $\frac{1}{5000}$th of a grain of the original soluble matter could be left in it. I then washed away the weak solution of acetate of potash as well as possible by means of alcohol, without, however, being able to remove all traces of that salt, although I used the alcohol somewhat dilute. The small quantity that remained could not materially affect the experiments I made upon it.

A portion of the substance thus prepared, when burnt in a large platina crucible, left a considerable quantity of ashes, slightly reddish coloured, which dissolved almost entirely in water. What remained was of a deep red, or rather brown colour, and was principally oxide of iron. The solution of the ashes was not at all alkaline; it gave a dense white precipitate with muriate of barytes; a very slight one with oxalate of ammonia; and with sulphate of alumina, large crystals of alum were formed in a few hours. It was sulphate of potash.

To remove all doubt of the precipitate having been sufficiently well washed to take away from it every thing that was not really insoluble in the menstrua I employed, and consequently the sulphate of potash, if that substance were not chemically combined with the cerulin, I mixed a large quantity of muriatic acid with the original solution in sulphuric acid, and formed the precipitate by means of muriate of potash. Then, having washed it as before, with the solution of acetate of potash, and afterwards with alcohol, I found that the solution of the ashes when the substance was burnt, gave indications with muriate of barytes, of abundance of sulphuric acid; while with nitrate of silver, no precipitate appeared; a quantity of small shining crystals alone being deposited after some time, which were sulphate of silver.

From these facts, I have no hesitation in concluding that this precipitate is a combination of cerulin with sulphate of potash. That salt forms more than a fourth of its weight. It may, therefore, be called *ceruleo-sulphate of potash*.

The salts of soda also form precipitates in the solution of cerulin with sulphuric acid, and these are likewise insoluble in solutions of potash or soda, though soluble to a certain extent in pure water. When heated, these ceruleo-sulphates dissolve even in solutions of their salts. On cooling, the greater part falls down again in blackish grains; a portion, however, remaining in

solution. The soda compound is evidently more soluble than that of potash. The washings of the former precipitate, with a cold solution of its acetate, are a little more coloured than those of the potash precipitate, with its acetate of the same strength. This last substance is totally insoluble in water containing one per cent. of acetate of potash, or even a half per cent. after two or three edulcorations. I have generally employed a solution of two parts dry acetate of soda in a hundred of water; and any quantity of such a liquid may be used without the quantity of the substance being materially diminished.

The salts of ammonia likewise form precipitates in the sulphuric solution of cerulin, when not much diluted. The precipitate dissolves readily in hot solutions of ammoniacal salts, and again separates when cold, the whole mass becoming curdy. I believe this substance to be a combination of cerulin with sulphate of ammonia, from the quantity of that salt which I found in it, when as well washed as possible. It is much more soluble, however, than the ceruleo-sulphates of potash and soda, and, therefore, cannot be washed so freely as these fixed alkaline compounds. Potash and soda, and their salts, decompose it. It dissolves in great quantity in boiling pure water, and in 40 or 50 parts of cold water. It has the same general properties with the more insoluble compounds.

A corresponding combination with barytes may be formed by decomposing ceruleo-sulphate of potash by muriate of barytes. The compound formed is extremely insoluble. An abundant blue precipitate is thus formed in solutions of ceruleo-sulphate of potash, containing so little sulphuric acid, that they are not troubled in the slightest degree by a barytic salt, when the cerulin has been previously destroyed by nitric acid.

Similar compounds may be formed with other bases, whose sulphates are difficultly soluble in water; but these I have not particularly examined.

The salts of magnesia have no power of precipitating cerulin from its solution. The whole of the sulphuric acid in the original solution may be saturated with magnesia, without any precipitate being formed.

Ceruleo-sulphate of Potash.

This substance is of so deep a blue, when wet with water, as to appear absolutely black. When dry, it has a shining strong copper-red colour. By transmitted light it is blue. It attracts water from the air with great rapidity. In two hours, a portion which had been dried attracted a tenth of its weight.

It is soluble to a considerable extent in hot water. Cold water takes up $\frac{1}{140}$th of its weight of this substance, and forms a solution so deeply coloured, that when diluted with 20 parts of water in a phial of an inch in diameter, it may just be seen to be

transparent. Water in a wine glass containing $\frac{1}{500\cdot000}$th of its weight of this substance is distinctly blue coloured.

The saturated solution is precipitated by spring water, and by every liquid that I have tried, except distilled water. From this it appears that the mere presence of any foreign substance in pure water greatly diminishes its solubility.

If the solution be diluted with 20 parts of pure water, it is still precipitated by solutions of the salts of potash and soda, lime, barytes, strontian, lead, and mercury. An addition of sulphuric or muriatic acid does not redissolve them. But neither ammonia nor any of its salts precipitate this weak solution. None of the salts of magnesia, zinc, or copper, nor the solutions of alum, sulphate of manganese, permuriate of tin, protosulphate or persulphate of iron, or nitrate of silver, decompose it. It is not precipitated by any of the acids, by infusion of galls, or by pure gelatine. Alcohol and ether do not precipitate the weak aqueous solution, though they do not dissolve any of the dry substance. Ceruleo-sulphate of potash dissolves readily in concentrated sulphuric acid, but not in concentrated muriatic acid.

When chloride of tin is mixed with the solution of this substance, its colour is immediately changed to yellow. This yellow product is not very soluble in water; it becomes blue again on the addition of any substance, as a salt of copper, capable of imparting oxygen to it.

When heat is applied to the blue substance, it does not melt; no purple vapour is given off, and in consequence of its being defended by the saline matter, a strong heat long applied is necessary for its being reduced to ashes.

When luminous objects, as the sun or moon, or the flame of a candle, are viewed through the blue solution of this substance, of the proper degree of intensity, they appear of a fine rich scarlet colour. It is worthy of remark, that a single drop of nitrate or sulphate of copper, mixed with a quantity of this solution, makes the same objects appear blue through it, although the general appearance of the liquid is not in the least degree altered. Zinc produces the same effect, though not so powerfully. Any acid restores to these mixtures the property of making luminous objects appear red, unless when a large quantity of copper has been added, which makes the liquid itself green.

Sir H. Davy* was the first to discover that a vegetable substance had the power of precipitating in combination with certain neutral salts, which are themselves abundantly soluble in water. The carbonates of potash, soda, and ammonia, and the chlorides of tin and of iron, are among the substances which that philosopher found undecomposed in combination with tannin, in the precipitates formed by these salts in an infusion of

* On Astringent Vegetables, Phil. Trans. 1803.

galls. It appears that cerulin acts a similar part, at least with the sulphuric salts. I am not aware, however, that any substance has been hitherto described by chemists which possesses the property I have found in the one here treated of, that of dissolving in pure water, and refusing to do so in neutral saline solutions which produce no change upon it. But in common life, some idea of this singular fact seems to have been long acted upon. Those who are in the habit of washing printed gowns, particularly dark ones, of colours not very permanent, always rince them in a solution of common salt, or at least in very hard water, before they hang them up to dry. The salt, they say, fixes the colour, and prevents it from spreading out into the white, which it always does when they are suffered to dry in a cool place, without such immersion.

On the Phenomena which are exhibited during the Formation of Cerulin.

Some of the phenomena which attend the action of sulphuric acid upon indigo, have been noticed by different chemists. Bergman, in 1776, observed, that when indigo in powder was sprinkled upon sulphuric acid, greenish clouds were produced, which became blue by the addition of a drop of water.* He added that the same effect was produced, but more slowly, without water. Haussman, of Colmar,† observed, that the acid in contact with indigo, became at first greenish-yellow, then deep-green, and at last blue. That gentleman remarked also, that the "effervescence and disengagement of sulphurous vapours, always observed in making the blue compound, leave no room to doubt that the acid exerts an action upon the particles of indigo, and that we should be wrong in considering this as a mere solution of indigo unaltered." Berthollet, in his excellent work on Dyeing,‡ considers the change that takes place a species of combustion; the sulphuric acid furnishing the indigo with oxygen, and thereby being converted into sulphurous acid. Dr. Bancroft, whose work appeared soon after that of Berthollet, conceived the solution to be oxygenated indigo combined with sulphuric acid. Hence he gave it the name of sulphate of indigo.§

Such, as far as my information goes, is the extent of our knowledge, or rather our opinions, upon this subject. I shall state what appearances I have myself observed during this process.

When indigo is put into sulphuric acid, it is dissolved, and the acid assumes a yellow colour. When this solution is dropped into water, it becomes instantly blue; but the substance so produced is by no means the same as that which is formed after

* Opusc. tom. v. p. 7. Edit. 1788.
† Journal de Physique for March, 1788.
‡ Vol. ii. pp. 50, 66, English translation.
§ On Permanent Colours, pp. 104, 132.

some time, without the assistance of water. It is indigo altogether unchanged, which precipitates, and leaves the sulphuric acid perfectly colourless. If the yellow solution be exposed to the open air in a watch glass for a short time, the blue colour is restored in the same manner, and the indigo falls down. This effect is produced, not by the action of the air, but merely by the absorption of moisture.

A considerable increase of heat takes place when the two substances are put together. There can be little doubt that this is caused by the sulphuric acid abstracting and combining with the 14·2 per cent. of water contained in the indigo.

If the yellow solution above mentioned be allowed to remain without dilution, it becomes blue in a few hours, and this is effected without the assistance of air, as I found by making the experiment in a small phial, the mouth of which was sealed up, as soon as the materials were put together. In consequence of the darkness of the liquid, these changes of colour can only be observed in the thin film which wets the empty part of the phial, when it is agitated.

All the chemists who have treated of this process, mention the formation of sulphurous acid during the solution of indigo, and, attributing this to the action of the indigo itself upon the acid, they naturally concluded that that substance became oxidated at the expense of the acid. But these chemists employed only the indigo of commerce in their experiments; a substance which contains more than half its weight of impurities, and great part of these vegetable matter. I have found that it is these impurities alone which decompose the acid; for during the solution of sublimed indigo, not a trace of sulphurous acid can be detected, though the heat of boiling water be applied for hours. Neither is there any production of hyposulphuric acid; for, if there were, it would be decomposed by the heat to which the liquid was exposed, or even by the presence alone of concentrated sulphuric acid, in which case sulphurous acid gas would be given off.

In less than 24 hours, if a slight degree of heat be applied, the indigo is entirely converted into cerulin; and, when mixed with water, it passes through the filter, leaving no residue whatever.

On the Constitution of Cerulin.

Since there is no production of sulphurous acid, nor absorption of air, during the formation of cerulin, it is clear that there can be no oxidation either of the carbon or hydrogen previously existing in the indigo. No carbon being deposited, and no gas evolved, during this process, prove also that the azote exists in the new substance, in the same proportion to the carbon that it does in indigo. That sulphuric acid does not enter into its composition, is evident from its precipitating with almost any sulphuric

salt, and carrying down no additional sulphuric acid of its own. It is only in the amount of combined water, then, that any alteration can possibly have taken place, and to ascertain whether in this case there has been an abstraction, or an addition of water to the indigo, it were only necessary to convert a given weight of that substance into cerulin, and to weigh the product, as M. de Saussure has done in the case of starch sugar. There are difficulties, however, which prevent such an experiment from being performed with any precision; principally the large quantity of sulphuric acid necessarily mixed with the product, and the solubility of the substance in water. I have contented myself with analyzing, by means of peroxide of copper, the ceruleo-sulphate of potash, after having ascertained as nearly as possible, by incineration, how much saline matter it contained. But, as this cannot be done with absolute precision, owing to the dissipation of a small portion of acid along with the vegetable matter, my results, particularly with regard to the hydrogen, were by no means so uniform as those which I obtained when operating upon indigo. All that is really necessary in this case, is to determine the quantity of carbon, which may be done with very little risk of error. The deficiency, after adding to the carbon the proportion of azote, and of free hydrogen found in indigo, is water.

Accordingly, I first of all dried a quantity of the blue substance at the heat of 212° in vacuo, and having weighed it as rapidly as possible, I exposed it to the air during a whole night, and noted the increase of weight from moisture. One portion of this was burnt to ashes. Another portion was ground with peroxide of copper, and the carbonic acid it produced was received over mercury. In this manner I found that 1 grain of pure cerulin yielded 4·5 cubic inches dry carbonic acid gas, which is equivalent to 0·5718 grain of carbon, reckoning 0·12708 grain as the quantity of carbon in a cubic inch of gas. The composition of the substance consequently is:

Carbon	57·18
Azote	8·79
Oxygen	29·32
Hydrogen	4·71
	100·00

This approaches so near to *indigo* + 4 *water*, that there can be little doubt such is its constitution.

1 atom azote	1·75 or	8·43
6 atoms oxygen	6·00	28·92
8 atoms hydrogen	1·00	4·82
16 atoms carbon	12·00	57·83
	20·75	100·00

The quantity of azote in proportion to the carbon, I found by experiment to be the same as in indigo; but as all my attempts failed to determine the amount of free hydrogen, I preferred stating all the numbers after carbon, by calculation from the analysis of indigo, which is susceptible of much greater precision. The heat of a spirit-lamp is quite sufficient for the analysis of most vegetable substances which are not mixed with saline matter; but with cerulin, it is necessary to employ the full red heat of a charcoal fire for its entire combustion by the peroxide of copper.

There is not the slightest proof that any combination exists between cerulin and sulphuric acid in the original liquid. Alkalies, it is true, precipitate it from the solution; and this has been supposed to be the effect of a superior attraction on the part of the acid for the alkali, by which the vegetable substance was left at liberty; but such a theory falls to the ground as soon as it becomes known that neutral salts produce exactly the same effect; that magnesia does not precipitate it at all, though it neutralizes the acid; and that cerulin is itself soluble in water. Cerulin dissolves, indeed, in sulphuric acid, and that more abundantly than in water; but this does not argue the formation of a compound which we are entitled to call sulphate of indigo. Such a solution differs in no respect from that of resins and other organic bodies in the same acid, or even from the solution of these substances in alcohol or ether.

Those who are fond of speculating upon the manner in which the elements of water are arranged in organic bodies, may find it curious that sulphuric acid should abstract water from indigo, and not from cerulin, a substance which contains three times as much oxygen and hydrogen; or that the same acid which robs indigo of its water, should immediately restore three times as much.

On a new Substance produced from Indigo by Means of Sulphuric Acid.

While engaged with these experiments, I discovered that if the action of sulphuric acid upon indigo be stopped at a certain point, a new substance, altogether different from cerulin, is produced, possessing rather singular properties. It is formed at the instant that indigo changes from yellow to blue by the action of sulphuric acid.

By the following process, it is obtained of greater purity than by any other method I have been able to discover. Prepare a quantity of indigo by boiling it in sulphuric acid diluted with three parts of water, and drying, after it is well washed. By such treatment, it is deprived of more than a third of its weight of impurities. Mix one part of this purified indigo with seven or eight parts of concentrated sulphuric acid in a stoppered phial, and agitate the mixture occasionally, till it becomes of a bottle-green colour. Then mix it with a large quantity of distilled

water, and throw it upon a filter. By continuing to wash the filter with distilled water, the liquid which at first passes through colourless becomes more and more blue, and after some time, all the indigo which has been changed, passes through. The colourless washings must be thrown away. The blue liquid contains the new substance in solution, and does not differ in appearance from a solution of cerulin. On the addition of muriate of potash, the new substance precipitates of a most beautiful reddish-purple colour, exactly similar to the colour of the vapour of indigo. Let this precipitate be thrown upon a filter, and washed with distilled water, till the liquid which passes through forms no longer a whitish, but a red precipitate with nitrate of silver. It may then be dried.

If instead of precipitating by means of muriate of potash, we take the blue liquid which passes through the filter after all the sulphuric acid has been washed away, but while it is still deeply coloured, and evaporate this to dryness, we obtain the new substance, not purple coloured, but blue, like cerulin; and but for the difficulty of separating entirely the sulphuric acid, this would be the best method of preparing it. Indeed in no other way is it obtained free from saline matter.

From the property possessed by this substance of becoming purple-coloured on the addition of a salt, I have called it *Phenicin*, from the Greek word φοῖνξ, purple; and, to prevent circumlocution, I shall hereafter make use of this term.

This substance, prepared with muriate of potash, is, when dry, of a brownish-black colour. Heated in a crucible, it gives off a little vapour of indigo. I was at first uncertain whether this might not proceed from indigo formed by the decomposition of part of the phenicin by the heat; but I shall state a fact which shows that the indigo may have another source, and that it may exist in a small quantity in the purple substance. After the filter is washed, till the washings are very slightly blue coloured, the liquid that passes through is precipitated blue, instead of red, by muriate of potash, and the precipitate consists of indigo with a little phenicin. Thus it appears that even indigo is, in certain circumstances, capable of dissolving in water. By drying the phenicin, prepared as I have stated, and redissolving it, a small quantity of indigo remains; but still the phenicin yields a little purple vapour when heated.

When the purple substance is burnt, it leaves about 15 per cent. of ashes, which dissolve in water, and consist of sulphate and muriate of potash.

Phenicin dissolves both in water and alcohol, and the solution in both cases is blue. It is precipitated again of its original purple colour by all saline substances whatever. Different salts, however, possess different powers of precipitation. Thus muriate of ammonia, chlorate and prussiate of potash, and muriate of soda, precipitate the phenicin entirely from about 60 times their

weight of any aqueous solution, and nitrate, muriate, and sulphate of potash, from about 100 times their weight. But the sulphates of magnesia, zinc, and copper, precipitate 2000 times their weight of a solution of phenicin; sulphate of iron about 3000 times; and alum and muriate of lime as much as 8000 times.

The phenicin being previously combined with a salt of potash, is not altered by being again precipitated by any alkaline salt. These salts do nothing more than saturate the water to such a degree, that the substance is no longer capable of dissolving in it. But the earthy and metallic salts combine with this substance, and displace the salt of potash previously united with it; and I have observed very little difference in the quantities necessary to precipitate solutions of different strengths. The precipitates formed by lime, barytes, alum, and copper, are totally insoluble in pure water, however well they may be washed. Those formed by iron and magnesia dissolve to a small extent, when freed from their former menstrua by filtration. Their solution is purple coloured.

Acids have no effect in preventing the precipitation of phenicin by saline bodies; and the precipitates once formed are not redissolved in the same liquid by the assistance of heat.

The method which I have given for preparing the new substance is tedious. As only a small part of the indigo is converted into phenicin, the quantity obtained each time is very small, and requires a great quantity of distilled water, and a long time to filter. But if we allow the indigo to be wholly converted into phenicin, its solution cannot be made to pass through any filter, however porous, or however well washed it may have been with water or ammonia. It was by accident that I discovered the possibility of filtering it when only a small portion of the indigo had had time to be changed; and it was only by preparing it in this manner that I found the purple colour to be owing to the presence of saline matter, and its own colour to be like that of cerulin.

The following is a method of preparing this substance in greater quantities, though not so pure. Mix together one part of indigo in powder, and 10 parts of concentrated sulphuric acid, in a phial, and agitate from time to time, till the blue colour, which the indigo loses at first, is completely restored. This, at the ordinary heat of summer, requires nearly three hours. At 100° Fahr. it is effected in about 20 minutes; and indigo mixed with sulphuric acid, at the heat of boiling water, becomes blue the instant the mixture is made. At 45° Fahr. 10 or 12 hours are necessary; and at lower degrees of heat, a still longer time, supposing always the quantity of materials small enough to cool very soon after mixture to the stated point. Pour this mixture into a large quantity of distilled water, and filter. Take the precipitate off the filter, wash it well with distilled water, contain-

ing the proportion of muriate of ammonia necessary to prevent the substance from dissolving in it, and filter again. Dissolve anew the precipitate in a large quantity of distilled water; heat the solution to drive off any particles of air which might prevent the impurities from subsiding, and let it stand two or three days in a tall vessel. Then draw off with a syphon as much as may be thought perfectly clear, leaving the remainder to be washed with more distilled water. Add to the solution any alkaline salt, till the substance be precipitated; then throw it upon a filter, and wash with distilled water till the liquid refuses to pass through.

The colour of the substance thus prepared is not much inferior in beauty to that prepared by the former process. Dried and burnt to ashes, a considerable quantity of earthy matter is always left, but very little of the alkaline salt that precipitated it. Its solution is always more or less purple, particularly if it be somewhat strong. In alcohol, it is completely blue, and the aqueous solution becomes blue when it is heated. After being dried, it does not dissolve in water.

When a solution of phenicin is precipitated, the liquid that remains is always more or less coloured with cerulin; and however often this be repeated upon the same material, a little cerulin is always left. If it has been heated, more cerulin is formed. It follows from this, that phenicin is changed into cerulin by the action of water alone.

Phenicin dissolves in the water of liquid ammonia without injury; but the fixed alkalies destroy it, though not very readily. Chloride of tin precipitates the solution, but gradually redissolves the precipitate, forming a yellow solution; and the phenicin is thrown down again of its own colour, by the salts of copper.

Phenicin dissolves readily in concentrated sulphuric acid, forming a blue solution; and if this be poured immediately into water, the greater part of it is precipitated again, the impurities of the acid being sufficient to prevent its solution in water. A portion is converted into cerulin, which remains in solution. When allowed to remain dissolved in sulphuric acid, it is soon entirely converted into cerulin; consequently in preparing phenicin by the second process, it is impossible to prevent the formation of a certain portion of cerulin.

Constitution of Phenicin.

The facts which I have stated to prove that cerulin differs from indigo only in containing more or less water, equally apply to this substance.

The perfect insolubility of phenicin in weak saline solutions enables us to determine pretty nearly how much of it a quantity of indigo is capable of producing. Ten grains of sublimed indigo were put into a small phial with 300 grains of sulphuric acid;

and after two hours and a half, when quite blue, the mixture was poured into a pint of water, and heated to boiling. It was then thrown upon a weighed filter, and washed; first with boiling water, in which had been dissolved a minute portion of sulphate of lime, and afterwards with boiling pure water. The purple substance remaining upon the filter, when thoroughly dried, weighed 9·61 grains; a portion of which being burnt, left a quantity of ashes, equal to 1·37 grain of the whole; consequently only 8·24 grains of pure phenicin had been produced. The washings, which were deeply blue coloured from the cerulin that had been formed, were put together; and when diluted with water to 95 cubic inches, exactly equalled in intensity a solution of 1 grain of indigo converted into cerulin, in 30 inches of water. Hence 3·16 grains of the indigo had been expended on the production of cerulin, and 6·84 grains had produced 8·24 grains of phenicin.

In another experiment, 4·2 grains of indigo produced 5·13 grains of phenicin; and in a third, 4·79 grains produced 5·65 grains. The mean of these makes 100 of indigo produce 120 of phenicin.

By analysis with peroxide of copper, I have obtained results which indicate a smaller increase of weight; and I am inclined to prefer these to the synthetic result, because the phenicin operated upon is much more pure, and the experiment altogether less liable to error. One grain of pure phenicin produced 5·085 cubic inches of dry carbonic acid gas, which contain 0·6462 grain of carbon. Hence, calculating as in the case of cerulin, the substance consists of

Carbon	64·62
Azote	9·91
Oxygen	21·49
Hydrogen	3·98
	100·00

This is very nearly *indigo* + 2 *water*, and its atomic proportions may be thus stated:

1 atom azote	1·75 or	9·46
4 atoms oxygen	4·00	21·62
6 atoms hydrogen	0·75	4·05
16 atoms carbon	12·00	64·87
	18·50	100·00

The experiments of Mr. Smithson, related in the Philosophical Transactions, have given us very correct ideas on the nature of a number of the vegetable colouring matters. It is sufficiently obvious that phenicin is not the principle which colours any of

the purple or blue vegetables examined by that chemist. I collected a number more of such purple flowers as are most commonly met with, and dipped them separately in concentrated sulphuric acid. But instead of becoming blue, they were uniformly changed to red, and formed red coloured solutions on the addition of water. Future inquiries, therefore, must determine whether phenicin exists ready formed in nature either in the blue or in the purple state.

Alcohol modifies remarkably the action of sulphuric acid upon indigo. A mixture of three parts of alcohol, of specific gravity 0·84, and two parts of acid, dissolves indigo without rendering it yellow, and the solution may even be filtered through strong paper. Probably a larger quantity of pure alcohol might be employed. On the addition of water, the indigo is precipitated without alteration; and if common indigo has been used, resin precipitates along with it. It may remain dissolved in this mixture any length of time without conversion into phenicin. A solution of phenicin in sulphuric acid may also be mixed with alcohol without precipitation, and the acid is rendered incapable of converting it into cerulin.

Article II.

Some Experiments on the Changes which take place in the fixed Principles of the Egg during Incubation. By William Prout, MD. FRS.*

"In the year 1816," says Dr. Prout, "I was induced to commence a series of experiments on the egg during incubation, with the view of ascertaining the nature of the changes which take place during that process. My inquiry was chiefly limited to the fixed principles; namely, the earthy and saline matters; but my attention was more particularly directed to the source whence the earthy matter, constituting the skeleton of the chick, was derived."

"With these views, the egg was analyzed in its recent and unaltered state, and at the end of the first, second, and third weeks of incubation. My experiments were chiefly confined to the eggs of the domestic fowl, but have been likewise partially extended to those of the duck and turkey. The investigation has been renewed, and the experiments repeated at various intervals since the period above-mentioned; but the difficulty of the

* Abstracted from the Philosophical Transactions for 1822, Part II.

subject and various accidents have prevented me from completing them till the present time; and the results, which, after all, are much less perfect than I could wish, I have now the honour of submitting to the Society."

Preliminary Experiments on the Egg in its recent and unaltered State.

It is here stated, that "the specific gravity of new laid eggs has been found to vary from 1·080 to 1·090;" and their apparent diminution in specific gravity is shown to depend "on the substitution of air for a portion of the water of the egg which escapes." A table is given, showing the gradual loss of weight of an egg during a period of two years. The original weight on the 19th May, 1820, the day it was laid, was 907·5 grains; and on the 19th of May, 1822, it had become reduced to 363·2 grains; having sustained a loss of 544·3.

"Hence we learn," says the author, "that a moderately sized egg loses on an average about ·75 grain in 24 hours, and that uniformly during a very long period......On being broken, the whole of the contents of this egg were found collected at the smaller extremity in a solid state; but on being put into water, they absorbed a large portion of that fluid, and assumed an appearance not much unlike those of a recent egg; the smell also was perfectly fresh."

"The relative weights of the shell, albumen, and yelk of different eggs," continues Dr. Prout, "are very different. With the view of investigating this point, and of obtaining something like an average, the following experiments were made. The eggs were boiled hard in distilled water, and the different parts weighed immediately in their *moist* state."

Shell and membrane.	Albumen.	Yelk.	Total.
80·0	394·3	289·0	763·3
108·0	593·0	273·5	974·5
107·3	575·8	236·2	919·3
71·5	516·5	215·0	803·0
103·0	503·7	269·3	876·0
107·0	515·3	273·4	895·7
93·2	605·5	252·4	951·1
92·7	515·7	257·0	865·4
96·8	510·6	210·8	818·2
77·6	567·4	241·5	886·5
93·7	529·8	251·8	875·3

A similar table is then given, in which the weight of each of these eggs is supposed to be 1000 grains; and Dr. Prout thus

continues: "Hence, if we suppose a recent egg to weigh 1000 parts, the relative proportions of the shell, albumen, and yelk, will be as 106·9, 604·2, and 288·9; and for the sake of easier comparison in all the subsequent experiments, the numbers are reduced to the above standard, or to the supposition that the original weights of the eggs employed were, when just laid, exactly 1000 grains.

"When an egg is boiled in water, it loses weight, particularly if it be removed from the water when boiling, and be permitted to cool in the open air; the water also on examination will be found to contain a portion of the saline contents of the egg. The loss of weight from boiling is by no means constant, but has been found to vary from 20 to 30 grains, on the supposition, that the original weights of the eggs employed were 1000 grains. On the same supposition, also, it has been found, that the quantity of saline matter obtained by evaporating to dryness the distilled water in which an egg has been boiled, amounts, at an average, to about ·32 grain. This saline residuum is strongly alkaline, and yields traces of animal matter, sulphuric acid, phosphoric acid, chlorine, an alkali, lime and magnesia, and carbonates of lime and magnesia; in short, of almost every principle existing in the egg. The carbonate of lime, however, is generally most abundant, and is obtained by evaporation in the form of a fine powder.

"The shells of eggs have been analyzed by Vauquelin and Merat Guillot; but these chemists seem to have over-rated the quantity of animal matter, and of phosphate of lime contained in them. When shells which had been dried in vacuo at 212°, were dissolved in dilute muriatic acid, the quantity of animal matter obtained was only about 2 per cent.; while the quantity of phosphates of lime and of magnesia never amounted to quite 1 per cent.; the rest was carbonate of lime mixed with a little carbonate of magnesia. When burnt, egg-shells, as Vauquelin has observed, yield traces of sulphur and iron.

"The *membrana putaminis*, on the supposition that the original weight of the egg be 1000 grains, weighs, when dried in vacuo at 212°, about 2·35 grains; and, on being burnt, yields traces of phosphate of lime.

"It may be observed here that the great differences in the quantities of the earthy matter existing in the shells of different eggs, have rendered the average totally inapplicable in these experiments, as will be shown hereafter; hence a more detailed analysis of this part of the egg was deemed unnecessary."

Saline Contents of the recent Egg.

Prior to giving the results of his investigation of this part of the subject, Dr. Prout relates the manner in which his analyses were conducted, premising generally, "that all the results were

obtained by combustion; and that the following observations to be understood as applicable to the whole of the experime subsequently related in this inquiry."

"The *albumen* burns with difficulty, unless care be taken remove the saline matter by frequent washings; but if this po be attended to, the whole of the carbonaceous matter may burnt off even in a covered crucible. In the subsequent exp ments, the saline and earthy matters were removed from crucible after combustion by distilled water; a little ammo was then added, and the whole permitted to remain at rest 24 hours; the clear solution containing the alkaline salts v now carefully poured off, and the insoluble residuum, consisti of the phosphate of lime and triple phosphate of magnesia a ammonia, after being washed with distilled water, was dried a weighed. The alkaline solution, together with the washings the earthy phosphates, were then evaporated to dryness, a exposed to a low red heat; and the weight of the saline residu being accurately noticed, the whole was again dissolved distilled water. A few drops of nitric acid being now added neutralize the excess of alkali present, nitrate of barytes v dropped into the solution as long as any precipitate fell. T precipitate was obtained by decanting off the solution as befo and, after being well washed, its weight ascertained: from t the quantity of sulphuric acid present was determined by cal lation.* To the solution, thus freed from sulphuric acid, nitr of barytes, and afterwards ammonia, were added. The phosph of barytes thus obtained was collected, washed and weighed before, and the quantity of phosphoric acid present obtained calculation.† Nitric acid was again added in slight excess the original solution, and nitrate of silver dropped into it as lo as any precipitate fell; from the chloride of silver obtained, quantity of chlorine present was estimated.‡ Lastly, the weig of the sulphuric and phosphoric acids and chlorine were ad together, and their amount subtracted from the weight of alkaline residuum formerly obtained by evaporation, the rema der, of course, indicated the quantity of potash and soda,§ carbonates of potash and soda present. Finally, the proport of the earthy phosphates to one another was determined, and quantities of the bases and acid obtained by calculation.

"The *yelk* of the egg is exceedingly difficult of combusti and indeed without proper precautions cannot be burnt at all

* On the supposition that the weight of the atom of sulphuric acid is 50, and tl barytes 97·5, oxygen being 10.

† On the supposition that the weight of the atom of phosphoric acid is 35, tl oxygen being 10.

‡ On the supposition that the weight of the atom of chlorine is 45, and of 137·5, that of oxygen being 10.

§ The quantity of soda equivalent to the sodium in union with the chlorine determined by calculation.

account of the large quantity of phosphorus it contains; which, by undergoing a partial combustion, forms a glassy coating that effectually excludes the contact of the air from the coal, and prevents its further combustion. After a variety of attempts, the following were the two methods employed: The yelk of an egg which had been boiled hard, and dried by exposure to the air, was rubbed in a mortar with a quantity of bicarbonate of potash. The mixture was then introduced into a platina crucible, and exposed to a strong red heat, till the flame had ceased to escape from a small hole in the lid. The crucible being now removed from the fire, its contents when cold, were again pulverised in a mortar with nitre. The mixture was then introduced a little at a time into the covered crucible till the whole was burnt. To the residuum, distilled water was added, which, of course, took up every thing but the earthy phosphates, which were separated and weighed; while the alkaline solution, like that before mentioned, obtained from the albumen, was submitted to the action of the appropriate reagents, and thus the quantities of the different acids present ascertained. In this manner, every thing was determined, except the proportion of alkaline matter present; and to ascertain this, other experiments with different yelks were made, in which lime and nitrate of lime were substituted for the bicarbonate and nitrate of potash."

The foregoing detail is succeeded by the statement, that the probability that the sulphuric and phosphoric acids obtained from the egg, exist in it naturally as sulphur and phosphorus, and that the metallic bases of the earthy principles "are to be considered as constituent principles of the primary animal compounds," induced the author "to state the quantities of the acids obtained separately from the bases." Dr. Prout also remarks, that as his experiments "were made almost entirely with the view of comparison only," he did not "enter into any very minute discriminations, which did not appear to be immediately necessary to his purpose."

The contents of the following table of the relative proportions of the saline principles of different eggs, were selected as examples from a variety of other analyses; the weight of each egg being reduced to 1000 grains:

	Sulphuric acid.	Phosphoric acid.	Chlorine.	Potash, soda, and carb. of ditto.	Lime, magnesia, and carb. of ditto.
No. 1. Albumen.	0·29	0·45	0·94	2·92	0·30
Yelk....	0·21	3·56	0·39	0·50	0·68
Total...	0·50	4·01	1·33	3·42	0·98
No. 2. Albumen.	0·15	0·46	0·93	2·93	0·25
Yelk....	0·06	3·50	0·28	0·27	0·61
Total...	0·21	3·96	1·21	3·20	0·86
No. 3. Albumen.	0·18	0·48	0·87	2·72	0·32
Yelk....	0·19	4·00	0·44	0·51	0·67
Total...	0·37	4·48	1·31	3·23	0·99*

Dr. Prout next gives the following analysis of the shell of the recent egg: The egg from which the yelk had been taken, which is the subject of the following experiment, had been boiled hard in distilled water, and the yelk, in its moist state, was found to weigh 316·5 grains. It was then partially dried by exposure to the air for several weeks; and to remove the remainder of the water was reduced to powder, and exposed to a temperature of somewhat more than 212°. The total loss of weight was 170·2 grains, which was supposed to indicate the quantity of water present. The remainder was now digested repeatedly in alcohol of specific gravity ·807, till that fluid came off colourless. The residuum was perfectly white and pulverulent, and possessed many of the properties of albumen; but it differed from that principle by the large proportion of phosphorus it contained in some unknown state of combination. The alcoholic solution was of a deep-yellow colour, and deposited crystals of a sebaceous matter, and a portion of a yellow semi-fluid oil. On distilling off the alcohol, the oil was obtained in a separate state. On cooling, it became nearly solid, and weighed 91 grains. The albuminous principle above-mentioned weighed 55·3 grains. Hence this yelk consisted of

* "Besides the above principles, *iron* is met with in almost all products of combustion; and the quantity in the egg, as the process of incubation proceeds, apparently increases considerably; but it was found impossible to ascertain its quantity with any degree of precision."

Water	170·2
Albumen*	55·3
Yellow oil	91·0
	316·5

"But I have reason to believe that the proportions of these ingredients differ a little in different eggs."

Experiments on the Egg at the End of the first Week of Incubation, or about the 8th Day.

At the end of the first week, it was found, on an average, that the egg had lost about 50 grains in the 1000, and the weights of its constituent principles in their moist state, were as follows: †

Unchanged albumen	232·8
Modified albumen	179·8
Liq. amnii, membranes, blood vessels, &c.	97·0
Animal	22·0
Yelk	301·3
Shell and loss	167·1
	1000·0

Dr. Prout here makes the following brief remarks on the general phenomena presented by the different constituent principles of the egg at those periods at which it has been submitted to examination.

"It has been remarked by many observers, that soon after the process of incubation has commenced, the yelk becomes more fluid than usual; and that as the liquor amnii increases, that portion of the albumen occupying the upper and larger end of the egg, begins to assume a peculiar appearance. In the present experiments (in which the egg was always previously boiled), the liquor amnii and portion of albumen in question, at the period now under consideration, exhibited somewhat the appearance of curds and whey. Nor did the analogy consist in mere appearance; for the curdy-looking matter, which was of a yellow colour, and which I have termed *modified* albumen, resembled the curdy part of milk in its properties, so far as to contain intermixed with it an oily or butyraceous principle. A portion of this oily principle, on being separated and examined, was found to be soluble in alcohol, of a bright yellow colour; and, in short,

* "This proportion of the albuminous principle does not differ much from that stated to exist in the yelk of the common fowl, by Mr. Hatchett. Philos. Trans. vol. cvi. p. 303."

† In the original paper, the weights of the constituents of two eggs are here given; the same is the case with the following series of experiments, and with all the remaining analyses except two; but as no striking differences are thus presented, only one of each kind is given in this abstract.

to possess all the properties of the yellow oil existing in the yelk. The yelk at this period, as before observed, has become more fluid, and appears larger, and of a paler colour than natural. Haller, indeed, asserts, that it has not increased in weight; but the above table renders the reverse very probable. These appearances of the albumen and yelk have induced most observers to believe that an interchange of principles takes place between them; while others seem to have mistaken the yellow modified albumen for the yelk itself. That an interchange of principles has taken place, at least under the above circumstances, there can be no doubt; yet the two are not indiscriminately mixed; for when the egg has been previously boiled, the yelk, though softer than natural, is nevertheless rendered of a firmer consistence than the modified albumen, and can thus be readily separated from it; there is, moreover, a distinct line of demarcation between them, arising, apparently, from the proper membrane of the yelk. Another argument in favour of the opinion of the intermixture of the albumen and yelk at this period, is derived from the following analyses of these constituent principles of the egg; from which it will be found that the quantity of the saline matter is diminished in the albumen, and increased in the yelk. It is a singular and striking fact, however, that although the oily matter of the yelk has made its way to the albumen, very little of the phosphorus, which exists in such large quantities in the yelk, has been removed with it."

	Sulphuric acid.	Phosphoric acid.	Chlorine.	Potash, soda, and carb. of ditto.	Lime, magnesia, and carb. of ditto.
Unchanged albumen.	0·13	0·27	0·19	1·03	0·18
Modified albumen, liquor amnii, animal, membranes, &c. . .	0·08	0·38	0·45	1·17	0·12
Yelk	0·09	4·03	0·60	0·80	0·68
	0·30	4·68	1·24	3·00	0·98

The results of an analysis made on the 10th day of incubation, show, that at this period "the proportion of phosphorus is somewhat diminished in the yelk, and increased in the animal and its appendages. The chlorine and alkaline principles seem also to have diminished in the yelk and to have increased a little in the albuminous portion."

Experiments on the Egg at the End of the second Week, or about the 15th Day of Incubation.

The egg has now lost, upon an average, about 130 grains in

the 1000, and the weights of its constituent principles are as follows:

	Grains.
Unchanged albumen.	175·5
Liquor amnii, membranes, &c	273·5
Animal	70·0
Yelk	250·7
Shell and loss.	230·3
	1000·0

"At this period, the animal has attained a considerable size, while the albumen has become diminished in a corresponding degree. The albumen has also acquired a very firm consistence, especially when coagulated by heat.

"The liquor amnii has become more fluid, and the *modified* albumen, formerly mentioned, has very much diminished in quantity, or disappeared.* The yelk, which at the end of the first week seemed to have increased in bulk and fluidity, has now apparently acquired its original size and consistence."

	Sulphuric acid.	Phosphoric acid.	Chlorine.	Potash, soda, and carb. of ditto.	Lime, magnesia, and carb. of ditto.
Unchanged albumen.	0·07	0·22	0·09	0·73	0·10
Liq. amnii, membranes, &c.	0·06	0·21	0·71	0·96	0·08
Animal	0·06	0·23	0·09	0·46	0·27
Yelk	0·30	3·34	0·16	0·68	0·69
	0·49	4·00	1·05	2·83	1·14

From the results of an analysis made two days later, or on the 17th day of incubation, it appears that at this period the yelk has yielded some of its phosphorus and sulphur to the other principles of the egg; that the chlorine has increased in the yelk, and diminished in the other principles; that the relative proportions of alkaline bodies remain much the same as on the 15th day; and that the earths have increased in quantity a little in the yelk, and very considerably in the other principles.

Experiments on the Egg at the End of the third Week, or at the full Period of Incubation.

At this period an egg has lost upon an average about 160

* "About this time Harvey, and other observers, have noticed the appearance of a curdy or coagulated substance in the æsophagus, crop, stomach, and intestines of the animal. Is this a portion of the *modified* albumen above-mentioned?"

grains in 1000; and the weights of its constituent principles in their moist state and without boiling, are as follows:

	Grains.
Residuum of albumen, membranes, &c.	29·5
Animal	555·1
Yelk	167·7
Shell and loss.	247·7
	1000·0

"At this period all the important changes of incubation are completed. The albumen has now disappeared, or is reduced to a few dried membranes and an earthy residuum (apparently consisting of the original earthy matter of the albumen which has remained unappropriated). The yelk is considerably increased in size,* and is taken into the abdomen of the chick; while the animal has attained a weight nearly corresponding to the original weight of the albumen, added to that lost by the yelk, *minus* the total weight sustained by the egg during incubation. The alkaline matters and chlorine which have been decreasing from the commencement of incubation, have now undergone further diminution in quantity, while *the earthy matters have increased in the most striking manner*. The other principles seem to have suffered very little change in quantity."

	Sulphuric acid.	Phosphoric acid.	Chlorine.	Potash, soda, and carb. of ditto.	Lime, magnesia, and carb. of ditto.
Residuum of albumen, membranes, &c. ..	0·04	0·12	0·09	0·23	0·12
Animal............	0·44	3·02	0·55	2·26	2·58
Yelk	0·04	1·06	0·03	0·06	1·26
	0·52	4·20	0·67	2·55	3·96

Dr. Prout observes, that the analyses in his paper are selected as the most perfect, from a variety of others made at each period, all of which confirm the results he has given: and he then states his conclusions from them, thus:

"These experiments, then, demonstrate, or render probable, the following circumstances:

* "This has been denied or doubted by some writers, especially Haller and Dr. Macartney."

"1. That the relative weights of the constituent principles of different eggs vary very considerably.

"2. That an egg loses about one-sixth of its weight during incubation, a quantity amounting to eight times as much as it loses in the same time under ordinary circumstances.

"3. That in the earlier stages of incubation, an interchange of principles takes place between the yelk and a portion of the albumen; that this interchange is confined on the part of the yelk to a little of its oily matter, which is found mixed with the above-mentioned albumen; that this portion of albumen undergoes some remarkable changes, and is converted into a substance analogous in its appearance, as well as in some of its properties, to the curd of milk; and lastly, that a portion of the watery and saline portion of the albumen is found mixed with the yelk, which becomes thus apparently increased in size.

"4. That as incubation proceeds, the saline and watery parts again quit the yelk, which is thus reduced to its original bulk; that in the last week of the process, it undergoes still further diminution in weight, and loses the greater portion of its phosphorus, which is found in the animal converted into phosphoric acid, and in union with *lime*, constituting its *bony skeleton*; and lastly, that this lime does not originally exist in the recent egg, but is derived from some unknown source during the process of incubation."

Dr. Prout concludes this valuable communication with some remarks on the uses of the yelk, and the apparent generation of earthy matter. The opinion "that the yelk is analogous to the milk of viviparous animals, but more concentrated, and that its chief use is to afford a pabulum to the young animal during incubation," is, he says, "corroborated in a striking manner by the present inquiry."

"With respect to the earthy matter found in the skeleton of the chick when it quits the shell," continues Dr. P. "I think I can venture to assert, after the most patient and attentive investigation, that it does *not pre-exist in the recent egg*; certainly not, at least, in any known state. The only possible sources, therefore, whence it can be derived, are from the shell, or transmutation from other principles. Whether it be actually derived from the shell, cannot be determined by chemistry; because, as we have seen, the shells of different eggs differ so much, that the application of averages is out of the question; and we are of course precluded from ascertaining the exact quantity of lime any particular shell originally contains. There are, however, very strong reasons for believing, that the earthy matter is not derived from the shell. In the first place, the membrana putaminis never becomes vascular, and seems analogous to the epidermis; hence the lime of the shell, which is exterior to this membrane, is generally considered by physiologists as *extra-*

vascular;* it is, therefore, extremely difficult to conceive how the earth in question can be introduced into the economy of the chick from this source, particularly during the last week of incubation, when a very large portion of the membranes are actually separated from the shell. Secondly, both the albumen and yelk contain, at the end of incubation, a considerable proportion of earthy matter (the yelk apparently more than it did originally); why is this not appropriated in preference to that existing in the shell? In opposition to these arguments, it will be doubtless stated, that the shell of the egg becomes brittle at the end of incubation, and appears to undergo, during that process, some other changes not at present understood. To which it may be answered, that this brittleness has been attributed to the separation of the membrana putaminis, and the exsiccation of the parts by so long an exposure to the heat necessary to the process of incubation; and in this manner all the known changes produced in the shell by incubation may, perhaps, be satisfactorily accounted for. Until, therefore, it be demonstrated that some other changes take place in the shell, I confess this argument does not seem to me to have much weight. I by no means wish, however, to be understood to assert, that the earth is *not* derived from the shell; because, in this case, the only alternative left me is to assert, that it is formed by transmutation from other matter; an assertion, which I confess myself not bold enough to make in the present state of our knowledge, however strongly I may be inclined to believe that, within certain limits, this power is to be ranked among the capabilities of the vital energies."

Dr. Prout has requested me to insert the following correction of a passage in his paper:—In the twenty-second page of the paper itself, or p. 398 of the Philosophical Transactions, line 8 from the bottom, *for* "after incubation," *read* "after it had left the egg."—*Edit.*

* "See an essay 'On the Connexion between the Vascular and Extra-vascular Parts of Animals,' by Sir A. Carlisle.—(Thomson's *Annals*, vol. vi. p. 174)."

Article III.

Summary of a Meteorological Table kept at Bushey Heath during 1822. By Col. Beaufoy, FRS.

1822.	Barom.	Ther.	Hygr.	Rain.	Evap.	Mean temp.	N	NE	E	SE	S	SW	W	NW
	Inches.			Inches.	Inches.									
Jan...	29·614	37·0	71·0	0·420	1·702	38·5	3	2	0	1	0	7	3	10
Feb...	29·612	41·5	72·0	1·080	2·118	42·6	1	1	0	4	2	16	1	3
March.	29·561	45·6	69·0	0·715	3·780	46·6	0	1	0	2	0	18	7	3
April..	29·454	46·3	64·0	2·482	3·230	47·2	0	10	1	5	0	8	0	6
May..	29·523	56·6	59·0	1·666	4·240	57·2	0	14	3	6	0	5	1	2
June..	29·636	64·3	56·0	0·780	6·520	65·3	1	11	5	2	1	6	0	4
July..	29·391	62·0	59·0	2·504	—	62·4	0	2	0	4	2	13	5	5
August	29·445	62·4	62·0	1·654	4·860	61·3	0	3	1	2	1	13	6	5
Sept...	29·503	55·2	64·0	1·060	3·760	56·1	0	14	2	1	0	6	4	3
Oct...	29·197	51·0	73·0	3·479	1·930	51·4	0	3	2	12	0	13	0	1
Nov...	29·171	45·4	78·0	3·097	1·550	46·3	0	4	0	4	0	21	1	0
Dec...	29·572	32·0	71·0	1·400	1·000	33·2	0	12	4	4	0	6	1	4
Mean.	29·482	49·9	66·6	20·337	—	50·7	5	77	18	47	6	132	24	46

Greatest height of the thermometer during the year was 85½°, June the 10th; least height, 18½°, December the 30th.

This table is similar to the one published in the *Annals of Philosophy*, Feb. 1822.

Article IV.

Astronomical Observations, 1822, 1823. By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Dec. 21. Emersion of Jupiter's third satellite	7^h	43′	58″	Mean Time at Bushey.
	7	45	19	Mean Time at Greenwich.
Dec. 25. Emersion of Jupiter's first satellite	9	28	49	Mean Time at Bushey.
	9	30	10	Mean Time at Greenwich.
Dec. 28. Egress of Jupiter's third satellite	8	26	28	Mean Time at Bushey.
	8	27	49	Mean Time at Greenwich.
Dec. 28. Emersion of Jupiter's third satellite	11	45	47	Mean Time at Bushey.
	11	47	08	Mean Time at Greenwich.
Dec. 29. Emersion of Jupiter's second satellite	9	36	20	Mean Time at Bushey.
	9	37	41	Mean Time at Greenwich.
Jan. 8. Emersion of Jupiter's first satellite	13	19	53	Mean Time at Bushey.
	13	21	14	Mean Time at Greenwich.

Article V.

An Account of the Process of smelting Copper as conducted at the Hafod Copper Works, near Swansea. By John Henry Vivian, Esq. FRS. MGS.

[Having lately been consulted by Messrs. Vivian and Sons, proprietors of the Hafod Copper Works, as to the means by which the inconvenience arising from the smoke of the copper works might be remedied, the following account, forming a part of Messrs. Vivian's statement, appeared to me to possess much general interest: I, therefore, requested, and readily obtained, permission to publish it.—*Edit.*]

The copper ores smelted in the works in South Wales are for the most part raised in the mines of Cornwall and Devon. They consist chiefly of yellow copper ore or copper pyrites, and the grey sulphuret of copper. The yellow ore is a compound of sulphur, iron, and copper, in nearly equal proportions. The grey ore, at least what is known in Cornwall under that denomination, is almost a pure sulphuret of copper containing about 80 per cent. of metal. Yellow ore, which is by far the most abundant, is usually accompanied by iron pyrites, or sulphuret of iron. The earthy minerals that occur with these metallic substances are chiefly siliceous, although in some mines the veins are of an argillaceous or clayey nature, while in others they contain fluor spar, or fluate of lime. Thus the component parts of the Cornish copper ores, as prepared for smelting, may be said to be sulphur, copper, iron, and from 60 to 70 per cent. of earthy matter. To these may be added, as accidental, tin and arsenic; for although these substances are not chemically combined with the copper, still as the ores of tin and copper frequently occur in the same vein, it is impossible to effect their complete separation by mechanical means. The quantity, however, compared with the substances above enumerated, is inconsiderable; for as the miner is not paid for the tin when contained in copper ores, it is of course his interest to separate it as clean as possible. The arsenic is derived from the arsenical pyrites which usually accompanies tin ores. The average produce in copper may be stated at 8½ per cent.

The ores are conveyed from Cornwall to Wales to be smelted on account of the supply of fuel, as not only carrying the smaller quantity to the greater, the ore to the coal, but because the vessels load back coal for the use of the engines of the mines. The principal smelting works are situated on the navigable rivers of

Swansea and Neath. The processes in a copper work are simple: they consist of alternate calcinations and fusions. By the former the volatile matter is expelled, and the metals previously combined with the copper oxidized, the general fusibility of the mass being thereby increased. The calcination is in fact a preparatory process to the fusion, in which the metallic oxides and earthy matters, being rendered specifically lighter than the metals, float on the surface, and are skimmed off as slags.

The furnaces in which these operations are performed are reverberatory, and of the usual construction. The substance to be acted on is placed on the body of the furnace or hearth, which is separated from the fire place by a bridge of bricks about two feet in thickness. The flame passes over this bridge, and, reverberating along the roof of the furnace, produces the required temperature, and escapes with any volatile matter that may be disengaged from the ore or metallic sulphurets through a flue at the opposite extremity of the furnace, which flue communicates with a perpendicular stack or chimney.

These furnaces are of two descriptions, varying in their dimensions and internal form. The calcining furnaces, or calciners, are furnished with four doors or openings, two on each side the furnace, for the convenience of stirring the ore, and drawing it out of the furnace when calcined. They vary in their dimensions, but are commonly from 17 to 19 feet in length from the bridge to the flue, and from 14 to 16 in width; the fire-place from 4½ to 5 feet across by 3 feet.

The melting furnaces are much smaller than the calciners, not exceeding 11 or 11½ feet in length by 7½ or 8 feet in the broadest part: the fire-place is larger in proportion to the body of the furnace than in the calciner, being usually from 3½ to 4 feet across, and 3 or 3½ feet wide, as a high temperature is required to bring the substances with as little delay as possible into fusion. These furnaces have only one door, which is in the front part of the furnace. The accompanying sketches may convey some idea of the construction of these furnaces; fig. 1 being a plan of a calciner; fig. 2 of a melting furnace.

Fig. 1.

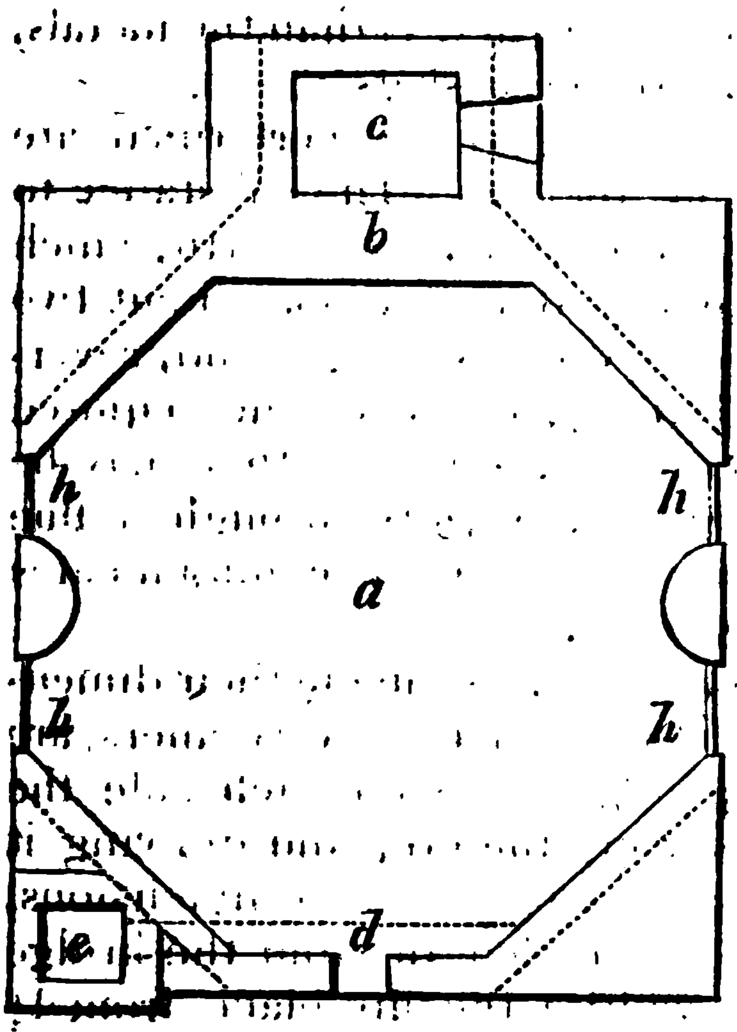
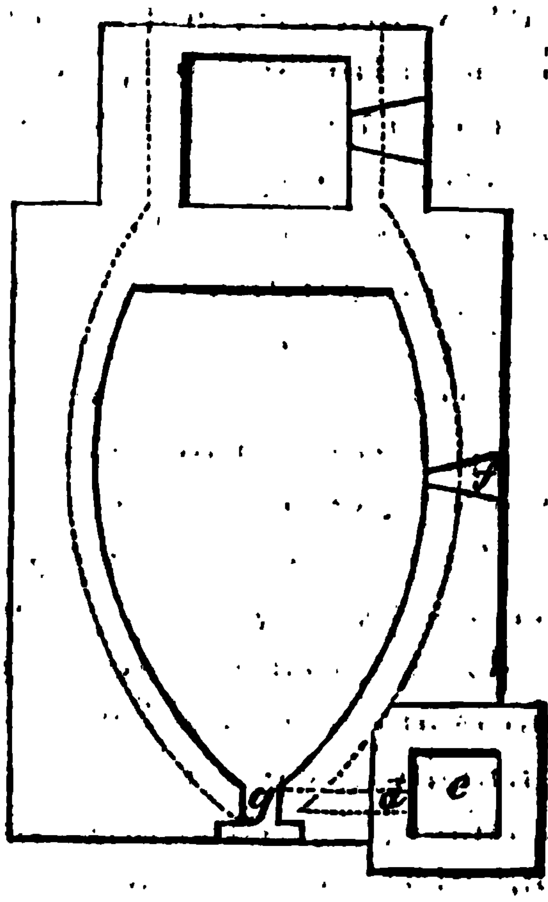


Fig. 2.



a. Hearth or body of furnace.
b. Bridge.
c. Fire place.
d. Flue.
e. Stack, or chimney.
f. Tapping hole.
g. Skimming door in melting furnace.
hhhh. Stirring doors in calciner.

The processes are conducted in the following order:

1. The copper ore calcined.
2. Calcined ore melted.
3. Coarse * metal from Process 2, calcined.
4. Calcined coarse metal melted.
5. Fine† metal from Process 4 calcined.
6. Calcined fine metal melted.
7. Copper from Process 6 roasted.
8. Coarse or blistered copper refined.

* Metal, means sulphuret when thus used; and coarse metal, sulphuret of copper and iron.

† Fine metal, ditto with larger proportion of copper.

Process I.—*The Calcination of the Ore.*

The copper ores, when discharged from the vessels in which they are brought from Cornwall, are wheeled into yards or plots contiguous to the works, and there deposited, one cargo over the other, so that, when cut down perpendicularly to be carried to the furnaces, a tolerably general mixture is formed of the ores of the county. This is always desirable in a smelting work, as, the ores being of different qualities and component parts, the one acts as a flux for the other. A more accurate mixture, calculated from the chemical analysis of each parcel of ore, might be preferable; but this on a large scale cannot be practised, as it would be impossible to keep the ores separate, on the different wharfs in Cornwall, to ship them separately, and to have sufficient space on the wharfs at the works to receive them.

The ore in the yard is weighed over to the calciner-men in boxes, containing each one hundred weight. These are carried on men's shoulders to the calciners, and emptied into iron bins or hoppers, formed by four plates of cast iron tapering to the bottom, placed over the roof of the furnace, and supported by wrought iron frames resting on its sides. From these bins, the ore is passed into the calciner through a hole in the roof immediately below the bottom of the hopper. Two of these bins are usually placed over each calciner, and nearly opposite the side doors, so that the charge of ore, when let into the furnace, may be conveniently spread, which is done by means of long iron tools, called stirring rabbles.

This charge of ore usually consists of three to three and a half tons. It is distributed equally over the bottom of the calciner, which is made of fire bricks or square tiles. The fire is then gradually increased: so that towards the end of the process, which lasts 12 hours, the heat is as great as the ore will bear without being fused or baked together. To prevent this taking place, and to assist the disengagement of the sulphur, the ore is frequently stirred during the operation, and fresh surfaces exposed. At the expiration of the 12 hours, the charge is drawn out through holes in the bottom of the calciner, of which there is one opposite to each door, and, falling under the arch of the furnace, remains there till it is sufficiently cool to be removed, when water is thrown over it to prevent the escape of the finer particles; it is then put into barrows, and wheeled to the proper depots. In this state it is called calcined ore. If the process has been well conducted, the ore is black and powdery. The dark colour is no doubt owing to a portion of the iron being oxidized during the process, by which the ores acquire an increased degree of fusibility. The quantity of iron oxidized during the first calcination is, however, small in proportion to the contents in the ore, as the metal is protected from the action of the air by the mass of earthy matter with which it is combined, and by the sulphur

and other volatile substances. The sulphur that is expelled is in no part sublimed as flowers of sulphur, but is all acidified, and the process being conducted with admission of atmospheric air is properly a roasting.

PROCESS II.—*The Melting of the Calcined Ore.*

The calcined ore is delivered, as in the raw state, to the workmen in boxes containing 1 cwt. each. The charge is deposited in the same manner in a bin placed on the top of the furnace, and from thence passed into the interior as required. When the charge is let down and spread over the bottom, the door of the furnace is put up, and well luted. Some slags from the fusion of the coarse metal or sulphuret are added, not only on account of the copper they contain, but to assist the fusion of the ore, being chiefly composed of oxide of iron. These are thrown into the furnace through the front door.

After the furnace is charged, the fire is made up, and the main object of the smelter is to bring the substances into fusion: it is, therefore, in this respect different from the calcining process. When the ore is melted, the door of the furnace is taken down, and the liquid mass well rabbled, or stirred, so as to allow of the complete separation of the metallic particles from the slags or earthy matters, and to get the charge clear of the bottom of the furnace, which is made of sand, and soon becomes impregnated with metal. The furnace being ready; that is, the substances being in perfect fusion, the smelter takes an iron rabble, and skims off, through the front door, the sand or slags consisting of the earthy matters contained in the ore, and any metallic oxides that may have been formed, which, being specifically lighter than the metals in the state of sulphuret, float on the surface. When the metal in the furnace is freed from slags, the smelter lets down a second charge of ore, and proceeds with it in the same manner as with the first; and this he repeats until the metal collected in the bottom of the furnace is as high as the furnace will admit of without flowing out at the door, which is usually after the third charge; he then opens a hole, called the tapping hole, in the side of the furnace, through which the metal flows into an adjoining pit filled with water. It thus becomes granulated, and collects in a pan at the bottom of the cistern, which is raised by means of a crane. It is then filled into barrows, and wheeled to the place appointed for its reception.

The slags received into moulds made in sand in the front of the furnace, are removed after each charge, and wheeled out of the work to the *slag bank*, where they are broken, and carefully examined; any pieces found to contain particles of metal, are returned to the smelter to be remelted; and unless the slag is very thick and tenacious, the copper which they may contain is found at the bottom. What is clean or free of metal is rejected. These slags are composed of the earthy matters contained in the ore

and the oxides of iron and other metals that were mixed with the copper. The oxide of iron gives them a black colour. The silex or quartz remains in part unfused, and gives the slags a porphyritic appearance.

In this process, the copper is concentrated, and a mass of stuff with which it was combined in the ore got rid of. The granulated metal usually contains about one-third of copper. It is thus four times as rich as the ore, and must consequently have diminished in bulk in the same proportion. Its chief component parts are sulphur, copper, and iron.

The most important point to be attended to in this process is to make a fluid good mixture of earths and metals, so that the copper which is combined with the sulphur, may from its greater specific gravity, settle at the bottom, and yield clean slags. This object is effected chiefly by means of metallic oxides, the slags from Process 4, which are melted with the ore, being almost wholly black oxide of iron. When the ores are very stubborn or difficult to melt, a box of fluor spar is added to the charge, but it is not desirable to increase the bulk of matter in the furnace unless required.

The men work round the 24 hours, and commonly melt in this time five charges. Under favourable circumstances, as fusible ore, strong coal, furnace in good repair, they even do six charges. They are paid by the ton.

Process III.—*Calcination of the Coarse Metal, the Product of the first Fusion.*

This is conducted in precisely a similar manner to the calcining of the ore The charge is nearly of the same weight; but as it is desirable to oxidize the iron, which is more readily effected in this process than in the ore calciners, where it is protected from the action of the air by the earthy matters with which it is combined, the charge remains 24 hours in the furnace, and during that time is repeatedly stirred and turned. The heat during the first six hours should be moderate, and from that time gradually increased to the end of the operation.

Process IV.—*Melting of the Coarse Metal after it has undergone Calcination.*

This is performed in furnaces precisely similar in construction to those in which the ore is melted; and with the calcined metal are melted some slags from the last operations in the works which contain some oxide of copper, as likewise pieces of furnace bottoms impregnated with metal, the proportion of each varying according to the stock or to the quality of the calcined metal.

The chemical effect which takes place is, that the oxide of copper in the slags becomes reduced by a portion of the sulphur which combines with the oxygen, and passes off as sulphurous acid gas, while the metal thus reduced enters into combination with the sul-

phuret. That there may be a sufficient quantity of sulphur in the furnace to promote these charges, it is sometimes necessary, when the calcined metal is in a forward state, to carry a small quantity of raw or uncalcined metal, so that a clean slag may be obtained.

The slags from this operation are skimmed off through the front door, as in the ore furnaces. They have a high specific gravity, and should be sharp, well melted, and free from metal in the body of slag. Such particles of metal as are drawn off, which, from the thinness of the slags, will commonly happen, should sink to the bottom of the slag while it is in the liquid state. These slags, as has been before observed, are melted with the ore, not only for the purpose of extracting the copper they may contain, but on account of their great fusibility, as, being composed chiefly of the black oxide of iron, they fuse readily, and act as solvents for other substances, earthy matters, &c. In some cases, the slags from the metal furnaces are melted in a distinct furnace with some small coal or carbonadeous matter, and in this case, the slags resulting therefrom are even sharper than those from the metal furnaces, they have a crystalline splendent appearance, and crystals are frequently to be observed in the interior.

The metal in the metal furnace, after the slag is skimmed off, is either tapped into water, as from the ore furnaces, or into sand beds, according to the mode of treatment it is to be subjected to in subsequent operations. In the granulated state, it is called fine metal; in the solid form, blue metal, from the colour of its surface. The former is practised when the metal is to be brought forward by calcination. Its produce in fine copper is about 60 per cent.

Process V.—*Calcination of the Fine Metal.*

This is performed in the same manner as the calcination of the coarse metal.

Process VI.—*Melting of the calcined Fine Metal.*

This is performed in the same manner as the melting of the coarse metal; the resulting product is a coarse copper from 80 to 90 per cent. of pure metal.

Process VII.—*Roasting.*

This is chiefly an oxidizing process. It is performed in furnaces of the same description as the melting furnaces, although distinguished by the appellation of roasters.

The pigs of coarse copper from the last process are filled into the furnace, and exposed to the action of the air, which draws through the furnace at a great heat; the temperature is gradually increased to the melting point, and the expulsion of the volatile substances that remained is thus completed, and the iron or

other metals still combined with the copper are oxidized. The charge is from 25 to 30 cwt. The metal is fused towards the end of the operation, which is continued for 12 or 24 hours, according to the state of forwardness when filled into the furnace, and is tapped into sand beds. The pigs, are covered with black blisters, and the copper in this state is known by the name of blistered copper. In the interior of the pigs, the metal has a porous honeycombed appearance, occasioned by the gas formed during the ebullition which takes place in the sand beds on tapping. It is in this state fit for the refinery, the copper being freed from nearly all the sulphur, iron, and other substances, with which it was combined.

Another mode of forwarding the metal for the refinery, still practised in some works, is by repeated roastings from the state of blue or fine metal; this, however, is a more tedious method of proceeding.

The oxidizing processes, whether conducted in a calciner or furnace, depending on the admission of atmospheric air into the body of the furnace, are greatly assisted by a patent, the exclusive right to which we purchased of Mr. Sheffield, the inventor, by which a constant stream of fresh air is kept passing over the metal. This is effected by means of a channel formed in the middle of the bridge, communicating with the external air at its two extremities, and with the interior of the furnace by square holes formed in the bridge at right angles with the channel. This has a very powerful effect in forwarding the process, and not only promotes the oxidation of the metals, but has the effect of igniting and consuming the coal smoke, assists in the disengagement of the sulphur, and, by keeping the bridge cool, admits of a more regular heat throughout the furnace.

Process VIII.—*Refining or Toughening.*

The refining furnace is similar in construction to the melting furnaces, and differs only in the arrangement of the bottom, which, is made of sand, and laid with an inclination to the front door instead of to one side, as is the case in those furnaces in which the metal is flowed out; the refined copper being taken out in ladles from a pool formed in the bottom near the front door. The pigs from the roasters are filled into the furnace through a large door in the side. The heat at first is moderate, so as to complete the roasting or oxidizing process, should the copper not be quite fine. After the charge is run down, and there is a good heat on the furnace, the front door is taken down, and the slags skimmed off; an assay is then taken out by the refiner with a small ladle, and broken in the vice; and from the general appearance of the metal in and out of the furnace, the state of the fire, &c. he judges whether the toughening process may be proceeded with, and can form some opinion as to the quantity of poles and charcoal that will be required

to render it malleable, or, as it is termed, to bring it to the *proper pitch.* The copper in this state is what is termed *dry.* It is brittle, is of a deep-red colour inclining to purple, an open grain, and a crystalline structure. In the process of toughening, the surface of the metal in the furnace is first well covered with charcoal. A pole commonly of birch is then held in the liquid metal, which causes considerable ebullition, owing to the evolution of gaseous matter, and this operation of *poling* is continued, adding occasionally fresh charcoal, so that the surface of the metal may be kept covered until from the assays which the refiner from time to time takes, he perceives the grain, which gradually becomes finer, is perfectly closed, so as even to assume a silky polished appearance in the assays when half cut through and broken, and is become of a light-red colour. He then makes further trial of its malleability by taking out a small quantity in a ladle, and pouring it into an iron mould, and when *set*, beating it out while hot on the anvil with a sledge. If it is soft under the hammer, and does not crack at the edges, he is satisfied of its malleability, or as they term it, that it is *in its proper place*, and directs the men to lade it out, which they do in iron ladles coated with clay, pouring it into pots or moulds of the size required by the manufacturer. The usual size of the cakes for common purposes is 12 inches wide by 18 in length.

The process of refining or toughening copper is a delicate operation, requiring great care and attention on the part of the refiner to keep the metal in the malleable state. Its surface should be kept covered with charcoal, otherwise it will go back between the rounds of lading, the cakes being allowed to cool in the pot, and others laded thereon. In this case, fresh poling must be had recourse to: over-poling is to be guarded against, as the metal is rendered thereby even more brittle than when in the dry state. Its colour becomes a light yellowish-red; its structure fibrous. When this is found to be the case, or as they say, *gone too far*, the refiner directs the charcoal to be drawn off the surface of the metal, and thus by taking down the side door, and exposing the copper to the action of the air, it is brought back to its proper pitch; that is, it again becomes malleable.

Are we to conclude from this, that copper in its dry state is combined with a minute portion of oxygen? or that some oxide of copper is diffused through, or combined with, the metal; that it is deprived of this by poling, and is then rendered malleable; and that, when gone too far, it is combined with a minute portion of carbon; that, like iron, either substance will render it brittle, and that it is only malleable in a certain intermediate state when free from both carbon and oxygen?* Or is the effect of the pole merely

* Another indication of the presence of oxygen in the dry copper, is afforded by the extraordinary action which it has upon the iron tools; they become bright, like iron in a smith's forge, and are consumed much more rapidly than when the copper is in a malleable state.

mechanical; that of closing the grain, and altering the texture or structure of the metal?

It is a remarkable circumstance that when copper is gone too far, it oxidizes slowly on the surface, thus strengthening the supposition of its being combined in that state with carbon, as that substance, from its union with the oxygen of the air, would prevent the oxidation of the metal. The surface of the liquid metal in the furnace is also more than usually splendent when over-poled, reflecting every brick in the roof, being then quite free from oxide.

Sometimes when copper is difficult to refine, a few pounds of pig lead are added to the charges of copper. The lead acts as a purifier, by assisting, on being oxidized itself, the oxidation of the iron or any metal that may remain combined with the copper, and not, as may be supposed, by uniting with the copper, and thereby increasing its malleability. This is a mistaken notion, and may lead to further embarrassment, as the smallest portion of lead combined with copper renders the metal difficult to *pickle*, or clean from oxide, when manufactured, as the scale or oxide will not rise clean from the surface of the sheets. The lead should be added immediately on the door being taken down preparatory to skimming, and the copper should be well rabbled, and exposed to the action of the air, so as to promote the entire oxidation of the lead.

Copper for brass making is granulated that its surface may be increased, so as to combine more readily with the zinc, or calamine.

This is effected by pouring the metal from the ladles in which it is taken out of the furnace into a large ladle pierced in the bottom with holes, and supported over a cistern of water. The water may be either hot or cold, according to the form to be given to the metal. When warm, the copper assumes a round form, and is called *bean shot*. When a constant supply of cold water is kept up, the metal has a light ragged appearance, and is called *feathered shot*. The former is the state in which it is prepared for brass wire-making.

Another form into which copper is cast, chiefly for exports to the East Indies, is in pieces of the length of six inches, and weighing about eight ounces each. These are called *Japan copper*. The copper is dropped from the moulds immediately on its becoming solid, into a cistern of cold water, and thus, by a slight oxidation of the metal, the sticks of copper acquire a rich red colour on the surface.

The charge of copper in the refining furnaces at Hafod is from three to five tons. The quantity of pure copper made weekly in the Hafod works, is from 40 to 50 tons. In the 12 months ending June 30, 1822, the purchases of ore amounted to 24,400 tons, containing 2144 tons of pure copper.

Contiguous to the Hafod smelting work is a powerful rolling mill.

It is worked by a steam-engine of 40 inch cylinder, and contains four pair of rolls. The cakes of copper are here manufactured into sheets and sheathings for export and home consumption. It is packed into cases which are lowered from the mills into vessels, and forwarded to the different markets. The *shruff*, that is, the edges (cut off on trimming the sheets), and the *pickle dust*, or oxide of copper, that is collected in the cisterns on cleaning them, are sent back to the refinery, and remelted.

In other mills situated on the river about two miles above these smelting works, and worked by water wheels, are also two pairs of rolls for sheathing copper; a pair of rolls for cold rolled sheathing; a pair of bolt rolls, and two hammers. And at Hafod is a nail manufactory for casting mixed metal nails and spikes of all descriptions, brasses for engines, &c.

These establishments contain 84 furnaces; and are lighted by gas lights, the operations being continued day and night.

In these works with the engine, and the shipping dependent on them, from 1400 to 1500 tons of coal are consumed weekly, affording employment to nearly 1000 people; or support to 3000 in family, and producing a revenue to the port of Swansea from 400*l.* to 500*l.* per annum, causing a circulation in the country of 1000*l.* a week; in fact, we need only look to the rapid rise and prosperous situation of the town of Swansea, to see at once the manifold advantages of the smelting establishments to the neighbourhood. At the period of the establishment of the first copper work on the Swansea river, about a century ago, Swansea was a mere insignificant village. In 1801 its population amounted to 6099, and in 1821 to 10,255, making an increase in the last 20 years of 4156.

The trade of the port has increased to such an extent that the number of vessels entering its harbour now amount to 2600 annually, producing a great revenue for the improvement of the navigation, and employing a very considerable number of seamen. Reckoning 10 voyages a year to each vessel, the copper trade would require constantly upwards of 100 sail, of 100 tons each. The Swansea market is frequented from the country for the distance of 15 to 20 miles, such is the demand for agricultural produce of all sorts; and land in the neighbourhood, owing to the wealth and prosperity of the town, lets for double its real agricultural value. The current expenditure of the smelting works in South Wales cannot be less than 200,000*l.* and their consumption and export of coal upwards of 200,000 chaldrons; and in Cornwall from 50,000 to 60,000 souls are dependent on the mines.

It appears from the statement in the second volume of the Transactions of the Royal Geological Society of Cornwall, that

the produce of the different copper mining districts of the kingdom, in the 12 months ending in June, 1822, was as follows:

Cornwall	9331 tons.
Devonshire	537
Staffordshire	38
Anglesea	738
Other parts of North Wales	55
Scotland	11
Ireland	738
	11042*

purchased by the following companies:

Vivian and Sons	2145 tons.
Williams, Grenfells, and Co.	2103
Daniell and Co.	1639
Crown Company	1257
Birmingham Company	1042
English Company	616
Fox, Williams, and Co.	580
Freeman and Co	504
Mines Royal Company	320
Rose Company	98
Anglesea Company, smelted	738
	11042*

Article VI.

Examination of Mumia, &c. By the Rev. J. J. Conybeare, MGS.

(To the Editor of the *Annals of Philosophy.*)

MY DEAR SIR, *Bath Easton, Jan. 14, 1823.*

It is well known that the substance found in the interior of Egyptian mummies, and thence termed mumia, once obtained not only a place, but a high reputation, in the Materia Medica. Its use was not entirely exploded so late as the days of Neuman, who justly ridicules the folly of such as believed it possessed of any virtues beyond those of other and *cleaner* preparations of a resinous and aromatic nature. Neuman too, was, as far as I am aware, the last person who subjected it to chemical examination.

* There is an error in this account; the amount is 11418, instead of 11042.—Edit.

He obtained from four ounces of this substance

	Ounce.	Drams.	Scruple.
Fixed salt	0	1	0
Gummy extract	0	5	1
Resinous ditto	1	3	1

The remainder (nearly two ounces) he considered as insoluble, and as composed (as I gather from a foregoing paragraph) of asphaltum and earthy matter. (See Neuman's Chemistry, p. 552.) Some later authors appear to suppose the mumia to consist entirely of asphaltum. (See Thomson's Chemistry, vol. ii.) Having obtained a portion of this substance taken from the skull of a mummy, and unquestionably genuine, I submitted it to a careful examination, and obtained the following results:

1. By digestion in water, it affords a small portion of extractive matter, of a dark reddish-brown colour, which, during evaporation by boiling, emits a disagreeable and somewhat urinous smell, readily oxidates, and thus becomes only partially soluble. The aqueous solution contains also a very minute portion of carbonate of soda.

2. Alcohol digested on the mass, previously acted on by water, dissolves a considerable portion. The solution is of a dark-brown colour; when mixed with water, it becomes turbid, and of a much lighter hue. No precipitate falls, nor does any alteration take place (except by evaporation) in the emulsion, if it may be so termed, thus produced. Evaporated to dryness in a glass vessel, the alcoholic solution leaves a residuum of a dark-brown colour, readily fusible by heat, semitransparent, of a glossy lustre, and powerful odour. This portion, therefore, may be considered as consisting of one, or perhaps more, of the gum-resins.

3. The portion which resisted the action of alcohol dissolved readily, and almost entirely in sulphuric ether. The solution was of a much deeper and blacker-brown than No. 2, and gave by evaporation a copious residuum, which, when dried, had all the characters of asphaltum.

4. There remained yet undissolved a very small portion of carbonaceous, and, perhaps, earthy matter, in which the lens detected some minute fibres not unlike those of decayed vegetables. As the mixture is evidently mechanical, and as I found by even rude experiments of comparison that of its principal ingredients (the resinous and bituminous), sometimes the one, and sometimes the other, was in excess, I have not attempted to give their proportions in numbers.

The mumia examined was taken, as before stated, from the interior of a skull. Herodotus informs us, that the so filling the skull (previously emptied of the brain) formed a part of that only which was deemed the most sumptuous mode of embalming.

The specimen, therefore, may be regarded as mumia in its most perfect state. It appears to differ from that examined by Neuman chiefly (supposing that I am right in considering his residuum of two ounces as asphaltum), in the small proportion which it gives of saline and extractive matter. It is probable that a mass taken from any other part of the body might retain the salt originally added for the purpose of preservation, and a greater proportion of decayed animal or vegetable matter, either of which would probably afford an extractive soluble in water. The carbonate of soda obtained in the present case could not have exceeded the proportion in which Neuman states himself to have found an alkaline salt in native asphaltum (seven grains in two ounces). Herodotus (it may be added), does not describe the substance used for filling the scull; he simply says, they injected certain *drugs* (φαρμακα). The compound used for filling the body, he states to have consisted of myrrh, cassia, and other aromatics. His editor Wesseling (who yet wrote after the publication of Neuman's works), has a note which insinuates a doubt of the accuracy of the historian on the authority of Nardius, and other early writers, who affirmed that they found nothing in the mummies which they examined but masses of bitumen. They were probably deceived by its external appearance, and unacquainted with the method of ascertaining its constituent parts. It is remarkable that Herodotus does not specify the use of bitumen, unless we regard him as including it in the general term aromatics (Θυωματα). Mumia, though long since discarded from the Pharmacopœia, has, I believe, retained some value as a pigment, especially with those artists who are somewhat of dilettanti in the choice of their materials. I am not sufficiently acquainted with the practical part of oil-painting to say with what justice. It may possibly afford a somewhat richer brown than the common asphaltum.

I have during the last week had an opportunity of ascertaining the indestructibility of common amber. A bead of that substance dug from a British tumulus on Mendip, where it must have remained on a low computation for 1600 years, though rifty, and covered externally with a thin crust nearly opaque, yet retains in the rest of the mass its peculiar fracture and transparency, and when exposed to the action of sulphuric ether, is dissolved as readily as specimens recently dug, and more carefully preserved.

Having obtained through the kindness of a friend (T. Grimes, Esq.) a further portion of the bituminous substance found near Merthyr Tydvil, to which I have ventured to give the name of

Hatchetine,* I am confirmed in my opinion as to its differing specifically from every variety of bitumen yet described. As in its external aspect, it partially resembles the napthaline obtained by Dr. Kidd,† I wished to ascertain whether it resembled that substance in one of its most striking empirical characters. I made, therefore, a small candle by covering a cotton wick with hatchetine, softened by the heat of a warm hand. On lighting it, I found that instead of producing the bulky smoke which issues from a candle of napthaline, it gave a remarkably clear and bright light, and when blown out exhibited no trace of the beautiful phenomena described by Dr. K.

Sulphuric ether dissolves it, as I have before stated, entirely; but somewhat sparingly. If thus treated in somewhat larger portions than the solvent is capable of taking up, it first separates into small laminæ of great tenuity and brilliancy, not unlike the scales scraped from the bleak for the purpose of manufacturing artificial pearls. After a time, these increase in bulk, lose their brilliancy, and concrete by uniting with a portion of the ether into a light mass, much resembling common opodeldoc. The increase in bulk is very striking, especially in a substance already so light as hatchetine; it must at least be as 40 to 1. The mixture is now found to contain two distinct compounds; the one a fluid solution of hatchetine in ether; the other, a combination of the same substances in a more solid form. The addition of water to the ethereal solution separates the hatchetine as a thin greasy pellicle, transparent, and of a consistency between that of oil and tallow. Neither by this process nor by evaporation have I ever found it to reassume its flaky or semicrystalline aspect.

I am, my dear Sir, very truly yours,

J. J. Conybeare.

Article VII.

On the Origin of the Accumulations of Bones in the Caves of the Vale of Pickering, in Yorkshire, and other Places. By G. Cumberland, Esq. MGS.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Bristol, Dec. 10, 1822.*

Much has been ingeniously written and reviewed on the subject of the accumulation of bones of various animals found in the caves in the vale of Pickering, in Yorkshire, and the probable mode in which they were brought there; but the general dispo-

* See *Annals of Philosophy* for Feb. 1821.

† See Philosophical Transactions for 1821.

sition to believe it to have been the work of the hyæna, I am free to confess does not satisfy me, since there is a much easier way to account for it, founded on a great event, now, I believe, disputed by no party of geologists whatever, and a strong proof of which we may acquire from the limestone caves near Plymouth, if any were wanted.

Wherever there are limestone rocks, or any usually termed secondary, immense irregular cavities are found, whose forms distinctly point out their origin to be *from subsidence*, and these are so numerous in Yorkshire, Derbyshire, and Somersetshire, that it is needless to insist on them. Those of the Peak, Pool's Hole, and those near Wells, are well known; but smaller ones are, in the neighbourhood of Bristol, continually opened by our quarrymen; and I have witnessed several, now broken up, particularly one at Redland, of some hundreds of feet in length, at different levels, yet connected by narrow passages with many smaller ones; the whole resembling, when the section was laid open, those settlements we often find in ancient castle walls, when undermined and sinking to decay.

These short of cavities are called in the west of England *swallowits*, from their being the conveyers of land-waters to the interior reservoirs in the limestone hills, and usually commence with a funnel-shaped cavity on the levels on the tops of the hills, and thus the great spring at Chedder is fed, which, in the autumn, bursts out from overflowing reservoirs; thus decidedly proving that great and terrible subsidences have occurred at some time or other, among these stratified hills, whose interstices probably were once nearly horizontal, resting on intervening clay, marl, or schistous clay, the material of which was no doubt the body that helped to launch them from their original position when first sapped by that fluid which once covered the earth, and by its lateral and downward pressure produced those effects which must have been the cause of a considerable change in the position of the rocks, such as is made evident on the sides of the Avon, near Bristol.

Now, Sir, I apprehend what the quarrymen did at *Oreston*, near Plymouth, viz. opening a way into one of these cavities by art, nature had done in the vale of Pickering by the action of the retreating waters of the great Noahtic flood, which undoubtedly must have torn away many large fragments of the sides of the hills in its passage downwards; and hence the discovery of this winding cave, so common in limestone hills. Thus much for the facts of the *two* caves. And it so happens, that in the cave, one mile from Plymouth, so effectually examined by Mr. Joseph Coldle of this place, there were found (and I have seen them) teeth of horses in abundance, those of deer, of several species of kine, many connected with their jaws, several specimens of wolves' and hyænas', a few of tigers', and of other animals a great number, some resembling otters'; they are also

of great variety of sizes, and many much worn down, of which he will no doubt, by and by, give a particular account to the public. Suffice it for our purpose, that these and an immense number of bones of horses, many of the legs complete, though small, were all found enclosed in a cavern that might almost have been said to have been *hermetically sealed* until the quarryers broke into it on cutting down a wall of limestone for masses to complete the Breakwater. We see, therefore, that these could not have been brought there by either wolves or hyænas, as all were involved in one common ruin when the hill closed on them at its subsidence; and, like the Yorkshire cave, this had at its bottom mud in abundance, by carefully searching into which Mr. Cottle disclosed these interesting remains, after some of the larger bones on the surface had been extracted by earlier visitors.

Among the teeth and bones, many are very well preserved; even many teeth have their enamel perfect, especially those of the tiger and the hyæna; and many of the bones are so saturated with the matter of stalactite as to be almost fossil.

From all these circumstances, it is plain that these animals were at some time congregated in this cave for security (for only necessity could have brought that about on account of their very different habits), and it seems probable to me, that to this circumstance alone we owe these great monuments of the Noahtic flood; for all bones that have not been so preserved must inevitably have partaken of that friction which we see has even rounded the quartz fragments, and left only the debris of tusks and teeth, and other deposits, among the alluvial gravels; and as the remains are quite similar in both the caves, I think we may be allowed to conclude, that both assemblages of animals had once been in a similar situation; that is, *totally enclosed by the subsidence of the rocks under which they had taken shelter from the rising waters at the deluge.* Much stress has been laid on the bones having been gnawed in the Yorkshire cave; but that, I think, can only prove that some outlived the others; and, being shut up, made their last meals on them; as rats, it is known, will do, when long enclosed in a vessel without other food than their own species. And as to the dung of hyænas, dogs, or wolves, found in the Yorkshire caves, that would naturally have been preserved where bones were not decomposed, being chiefly, if not altogether, a phosphate of lime, I believe. With the greatest respect for the opinions of the gentlemen who have given us their very plausible conjectures on the first cave, I take the liberty to request your publication of mine; for truth must be the object of us all. Yours, &c.

G. CUMBERLAND.

P.S. Animal matter of half an inch in thickness, it is said, covered the surface of the mud, which was about two feet deep; but none of this has been preserved for examination.

Article VIII.

Account of a new Mineral. By Mr. A. Levy, MA. of the University of Paris.

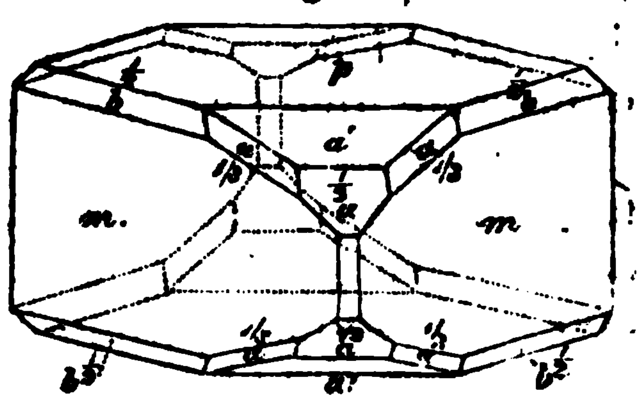
(To the Editor of the *Annals of Philosophy.*)

SIR, *Great Russell-street, Bloomsbury, Jan. 23, 1823.*

In the select collection of minerals lately Mr. Heuland's small private collection, but now the property of C. H. Turner, Esq. I found two specimens from the Seisser Alpe in the Tyrol, containing small brilliant transparent crystals, which were described as datolite; but which, from their crystallographical characters, ought, I believe, to be separated from that mineral species.

In order that the difference between the two substances may be the better shown, I shall first describe one of the new varieties of datolite which I have observed in the same collection. This variety is represented by fig. 2, and indicates for the primitive form a right rhombic prism, the lateral planes of which would correspond to the faces marked *m*, and the base to the face *p*. Moreover, in order to make the face $\overset{\frac{1}{3}}{a}$, the result of a simple decrement on the lateral angles of this prism, it is necessary to determine its height by assuming that the face a^1 is produced by a decrement by one row on the obtuse angle of the base. If the height were to be determined by any other condition, it would make the faces $\overset{\frac{1}{3}}{a}$ the result of an intermediary decrement. The dimensions of the right rhombic prism being thus determined, not only the modifications of the crystal represented in fig. 2, but all that I have observed, result from very simple decrements on its different parts; there can be no objection, therefore, to consider it as the primitive form. Now I find, by the reflective goniometer, that the incidence of

Fig. 2.

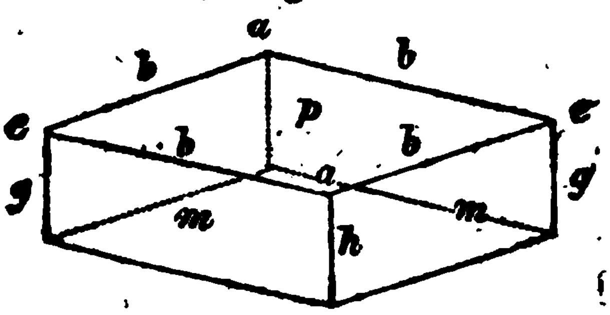


P on *m* is....................	90°	0′
m on *m*....................	103	25
a^1 on *p*....................	147	46

The first of these incidences was to be expected from the law of symmetry: it results from the other two, that the primi-

tive form of datolite may be considered as a right rhombic prism, fig. 1, of 103° 25′, in which one side of the base is to the height, in the ratio of sec. 51° 42′ 30″ to tang. 32° 14′, or, nearly, as 13 to 15. Haüy, in the new edition of his Traité de Minéralogie, has preserved the determination he had previously given of the primitive form of datolite. It is, according to him, a right rhombic prism of 109° 28′, in which the length of one side of the base is to the height in the ratio of 3 to $\sqrt{10}$. This determination differs from the preceding by 6° 3′ in the incidence of the lateral planes. It is not likely, therefore, he had measured the same angle as I have. I suppose that the lateral planes of his primitive form are those of some modification of the one I have adopted, composed of two pairs of parallel planes, and must consequently be the result of some decrement either on the angles of the base, or on the lateral edges. This modification, two planes of which should be inclined at an angle of 109° 28′, I have never observed, nor does any simple law of decrement give any thing very near it.

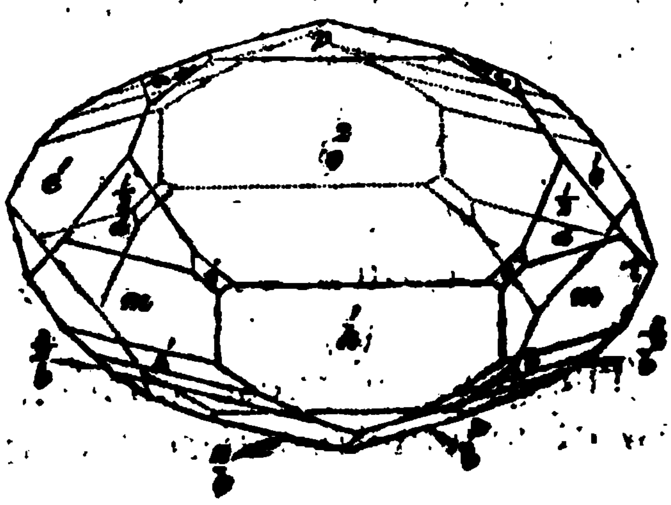
Fig. 1.



Prof. Mohs in his Natural Historical System of Mineralogy, has called the crystallization of this mineral *hemi-prismatic*, and as this denomination is applied only to those substances, the crystalline forms of which may be conceived to be derived from an oblique rhombic prism, it might be inferred that he does not consider the primitive form of datolite to be a right rhombic prism. But it appears to me that this inference would be in contradiction with the incidences he has given for the faces of the octohedron he takes for the *ground* form of this substance, since they are calculated in the hypothesis the result of a decrement by one row on the edges of the base of the primitive form adopted by Haüy. However, there can be no doubt, I presume, from what I have stated, that the forms of datolite can be derived from a right rhombic prism.

I shall now describe the crystals from the Tyrol which I have already mentioned. The greater number of them have the form represented by fig. 4, which is obviously a rhombic prism, the edges and angles of the base of which are not similarly modified. Consistently with the law of symmetry, this form cannot be derived, like those of datolite, from a right rhombic prism, but only from an oblique one; and, therefore, according to the

Fig. 4.



principles of classification generally adopted, these crystals should form a distinct mineral species.

The face marked p in fig. 4, is always very small; and in the crystals I have measured, it is entirely obliterated. The angles which I could measure with the greatest accuracy, were the incidences of m on m, that of $d^{\frac{1}{2}}$ on m, and that of e^1 on the similar face below. I could, besides, deduce from my measurements, that, supposing the faces m, m, to correspond to the lateral faces of the primitive, the plane p to the base of it, and e^1 to be the result of a decrement by one row on the angles e of the base, then $d^{\frac{1}{2}}$ might be considered as produced by a decrement by two rows in height on the edges d. These were the data from which I had to determine the dimensions of the primitive form, as the other incidences that I measured could not be relied upon. For this purpose I made use of the following formulæ relative to an oblique rhombic prism; the investigation of which presents no difficulty.

$$x = \frac{h \sin. (p, m) . \sin. (d^x, m)}{\sin. (m, m) . \sin. (d^x, p)}$$

$$y = \frac{h \sin. (p, m)}{\sin. \frac{1}{2} (m, m) . \text{tang.} (e^y, p)}$$

h is the length of the lateral edge, one side of the base being supposed to be equal to one, and (m, m), (p, m), (d^x, m), (e^y, p), denote, respectively, the incidences of m on m, of p on m, of a face produced by x rows in breadth on the edge d of the base on m, and of a face produced by y rows in breadth on the angle e of the base on p*. To apply these formulæ to the present case, it is sufficient to observe, that here $x = \frac{1}{2}$ and $y = 1$.

Substituting these values in the two preceding formulæ, and dividing the one by the other, there will arise

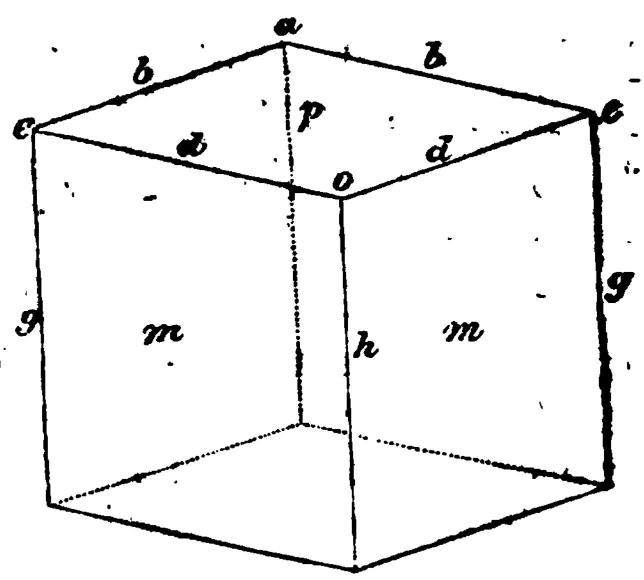
$$\text{tang.} (e^1, p), \sin. (d^{\frac{1}{2}}, m), = \cos. \tfrac{1}{2} (m, m), \sin. (d^{\frac{1}{2}}, p).$$

The only unknown quantity in this equation is the angle $(d^{\frac{1}{2}}, p)$, as the others are precisely those which I could measure with accuracy. The angle (e^1, p), is not the immediate result of observation, but is evidently the supplement of half the incidence of e^1 on the similar face below it. The angle $(d^{\frac{1}{2}}, p)$, will, therefore, be easily calculated, and by subtracting 180° from the sum of the two angles $(d^{\frac{1}{2}}, p)$, $(d^{\frac{1}{2}}, m)$, the value of the angle (p, m), will be obtained. This last angle being known, the first

* I think that this notation, which consists in denoting the incidence of two faces, by placing their crystallographical signs, separated by a comma, between two brackets, if generally used, would considerably abridge the language of crystallography. I believe it will also be found very convenient to write, as I have done in figs. 2 and 4, on each face of the drawing of a crystal, its crystallographical sign. It is certainly preferable to the method used by Haüy and the Count de Bournon; in which each new modification is designated by a new sign which has no reference to the decrement that produces it.

formula will give the value of h, and thus the dimensions of the primitive form will be completely determined. There will then be no difficulty in calculating from the measured incidences of the other faces, either on m, or some other known plane, the indices of the decrements from which they are derived. Thus I find that the primitive form may be supposed to be an oblique rhombic prism, fig. 3, in which the incidence of m on m is 115° 45′, that of m on p 91° 25′, and one side of the base is to the lateral edge nearly in the ratio of 15 to 16. The letters placed on the faces of the crystal, represented in fig. 4, indicate respectively the decrements which produce them, and their incidences on p and m are as follows:

Fig. 3.



Incidence of h^1 on p	....	91°	41′	30″
e^1 on p	....	128	45	0
e^2 on p	....	148	19	0
o^2 on p	....	138	3	0
$d^{\frac{1}{2}}$ on m	....	157	6	30
b^1 on m	....	138	55	10
$b^{\frac{3}{4}}$ on m	....	127	6	30
b^2 on m	....	119	13	0

I was unable to measure the faces marked i in the drawing: they result from an intermediary decrement. The intersections of these faces with the two faces m and o^2 appear to be parallel. Therefore, by supposing the face o^2 the result of a decrement by one row instead of two, the faces i would be produced by simple decrements on the lateral angles o of the prism. In this hypothesis, the ratio of h to d would be half what I have taken it, and the indices of all the modifications observed, except that of h' should also be divided by 2. The oblique rhombic prism, the dimensions of which have just been stated, does not possess the property which, according to Haüy, belongs to all primitive forms of this kind, and which consists in their having such dimensions that the diagonal joining the solid angle o, fig. 3, with its opposite, is perpendicular to the edge h. But in the present case, the incidence of p on m being nearly 90°, it is very obvious that if the ratio between h and one side of the base of the prism were determined by such a condition, it would be considerably less than I have made it; and consequently that even on the supposition that the observed modifications could be

derived from a prism with such dimensions, there can be no doubt but that the indices of their decrements would be very complicated, when compared with those resulting from the ratio of the edge *h* to the edge *d*, which I have assumed. Thus, although the alleged property of oblique rhombic prisms may really exist in the primitive forms of some substances, yet this example proves that it is not of universal occurrence.

I am sorry that I cannot add to the determination of the primitive form of this substance, a satisfactory account of its physical and chemical characters, but the quantity of it which I could procure was so small, that no very decisive experiments upon it could be made. Dr. Wollaston, however, to whom I never applied in vain for assistance, was so kind as to examine a very minute quantity of it; and he found it to contain the same principles as datolite. It still remains to determine in what proportion these are combined, if in the same as in datolite, or as in botryolite, or whether it differs from both in this respect.

The mineral is sufficiently hard to scratch fluor spar, but it will not scratch glass. I found an indication of cleavage, parallel to a plane passing through the small diagonals of the bases of the primitive prism. In one of the two specimens in which I have observed it, it is mixed with carbonate of lime; and in the other, with the same substance, and with small flat crystals of apophyllite.

Should it be found necessary to designate this substance by a new appellation, when an exact and complete chemical analysis of it shall have been made, I would propose to call it Humboldite, from that eminent philosopher to whom natural science is so much indebted; and I hope that he would see, in the liberty I had taken of associating his name with this new mineral, no other motive, than my desire to evince the respect and gratitude I have for him.*

I am, Sir, yours, &c.

A. LEVY.

* It may be useful to remark, that the name of Humboldt is already recorded in mineralogical nomenclature; for the protoxalate of iron found by M. Breithaupt in friable lignite at Kolowserux, in Bohemia, has been denominated *Humboldtine* by its analyst, M. de Rivero.—(See Ann. de Chim. xviii. 207, or Journal of Science, &c. xii. 428.)—*Edit.*

Article IX.

Memoir illustrative of a general Geological Map of the principal Mountain Chains of Europe. By the Rev. W. D. Conybeare, FRS. &c.

(*Continued from* p. 16.)

[Some copies of the map having been, in the haste of publication, incorrectly coloured, the reader is requested to compare the colours with the dotted outlines. Where they do not coincide, the former are erroneous; the errors are generally of a nature which will admit a ready correction by these means. It will be seen that some parts of the present article are taken from a former publication by the same author.]

Carboniferous Series.

The carboniferous series, considered in the largest acceptation of the term, comprises, besides the coal measures properly so called, certain other formations of limestone and sandstone, so associated with them, that the attempt to separate them would materially interfere with the clearness of a natural division.

1. The coal measures, properly so called, consist of numerous alternations of seams of coal with beds of slate clay and sandstone.

2. These repose on an alternating system of shale and grit, in which the peculiar limestone characterising the coal districts makes its first appearance in any considerable quantity. The coal seams here become few and unimportant.

3. A system succeeds characterised by the predominance of the limestone called, from its relation to the coal fields, carboniferous. The coal seams in this system are reduced to slight traces which have never yet been worked.

4. A vast deposit of quartzose conglomerate and sandstone, commonly called old red sandstone, forms the lowest formation in this great natural order. No coal has yet been observed in or below this formation.*

5. Trap rocks of various kinds (basalt, greenstone, porphyry, and amygdaloid) occur associated with the preceding formations in various modes of combination, as dykes, irregularly interposed or overlying masses, and sometimes as alternating beds. The phenomena are such as often to render it doubtful whether they are of cotemporaneous origin with the rocks among which they

* The case of Portishead Point cited by Mr. Weaver as affording an example of this position is erroneous; the coal is there associated with the regular sandstone of the coal measures, and reposes very distinctly on the great carboniferous limestone. Mr. W who had not visited the place himself, was misled by an incorrect report. I hav repeatedly examined the spot in company both with Prof. Sedgewick and Prof. Buckland.

occur; and in the opinion of many geologists favour the hypothesis of their ignigenous formation.

All these formations are shown in their constant and regular order of succession in the greater part of the English and Irish coal fields; and the only Scotch coal field of which we have any distinct account (that of Clackmannan), entirely harmonises. The structure of the carboniferous districts of the Netherlands, and (if we may judge from Beudant's description), of Hungary also, is exactly parallel. In some instances, however, the third and fourth systems being deficient, the coal measures repose immediately on the transition limestones, slates, &c. (as in Colebroke Dale, and Dudley, in England; in the Hartz, and many places on the Continent.

The order of superposition, however, is never inverted, nor *is there one single instance on record in which any workable seam of coal has been found below the third or fourth system above enumerated,* unless we consider the anthracite sometimes associated with transition slates, and which may be readily distinguished from the true coal formation, as an exception.

The limestones of the third series, and the conglomerates and sandstones of the fourth, are generally referred by continental geologists to the transition class. (See Von Raumer on the Slate Mountains of the Netherlands, &c. Daubuisson, Geologie; Beudant, Hongrie; Humboldt, &c.). The representations of every one of the above writers render it absolutely impossible to confound the rothetodteliegende of Germany with the conglomerates of the fourth system above described.

I have, in another work, assigned my reasons at length for constituting a separate order to include the whole of these four systems rather than referring any part of them to the transition class with which, however, they are very nearly allied.

The geologists of the Continent very commonly consider the *rothetodteliegende* (a formation immediately *overlying* the coal measures), as forming part of this series.

I prefer the view entertained by Prof. Buckland, who has, in repeated journeys in the north of Germany, minutely examined the relations of the rotheliegende with reference to this question, and who considers it as the lowest member of the great sandstone series forming the next natural group above the carboniferous series. Though conscious how little weight my own evidence will add to this high authority, I may briefly state that my own personal examination of the Thuringerwald led me to the same conclusion. I have only at present to repeat my assertion, that Lehman, Freisleben,* Von Buch, Von Raumer, Karsten, Keferstein, Daubuis-

* Although I purposely avoid entering into details at present, I shall subjoin one extract from Freisleben, which is entirely decisive. He observes that some geologists are inclined to consider the coal rocks and the rotheliegende as subordinate members of one great formation; but opposes his own view of the subject to theirs, stating that he considers them "als zwey einander zwar ganz nahe stehende, *aber dennoch von einander-*

son, and Humboldt, all concur in assigning to the *great mass of the rothetodteliegende* a position above the coal measures. As that assertion has been questioned, I shall shortly support it by detailed quotations in their own words; and I have only to regret a controversy which renders inevitable a method of proof that must necessarily occupy so many pages usually devoted to much more interesting and valuable matter.

I have thought it necessary thus far to explain the principles on which I proceed in separating the consideration of the rothetodteliegende from the description of the continental coal districts.

A rock placed exactly in the situation of the rotheliegende (that is, between the coal measures and magnesian lime), is specified in Smith's map of Yorkshire, under the name of the Pontefract rock. He classes it with the coal measures; but the course he assigns to it is unconformable to these, and conformable to the superjacent magnesian limestone. This rock ought to be carefully examined and described.

It should be observed that as the rocks overlying the coal measures cover them unconformably throughout England, instead of succeeding in a regular and conformable series, we have no evidence that the highest beds of the coal formation are

zu trennende formationen," as two very nearly allied formations, but nevertheless *distinct from each other;* and, conformably with this view, he *carefully distinguishes* certain coal seams which, according to him, actually are subordinate to the rotheliegende from the true coal formation. "My observations," he states, "lead to the conclusion, that *a part of the beds hitherto referred to the coal formation* (*properly so called*) *ought to be separated from that formation, and regarded as subordinate to the rotheliegende.* "*Ein theil der bisher zu den eigentlichen Steinkohlen gebirgen gerechneten Steinkohlen flosse von solchen abzusondern, und dem rothliegenden unterzuordnen ist.*" Mr. Weaver has suffered himself to be misled by neglecting to advert to the circumstance, that the passages he has quoted from Freisleben, as proving that the coal formation *generally* is included in the rotheliegende, have no kind of reference to the "eigentlichen Steinkohlengebirgen," the *proper coal formation*, but are confined to that part of the series thus carefully *separated* from it by that author on account of this very position. The cause that seems to have led to this misconception is, that the two formations being conterminous, the true coal formation, and these subordinate beds, often occur *nearly* in the same localities. A careful collation of the map accompanying Freisleben's work with his text removes in the most convincing manner this source of confusion.

The plan of Freisleben's work does not extend to the coal formation properly so called. I should add that the passages above cited from Freisleben are not incidental notices; but form the express declaration of his opinion on this point deliberately pronounced in the section dedicated to the consideration of the relations to which they refer.

I refer to the account of the environs of Glatz by Von Buch for his testimony in this controversy. Dr. Anderson's notes in this translation of that work will convince Mr. Weaver that I am not singular (as he appears to suppose) in my interpretation of Freisleben's sentiments, but have the authority of those best versed in the geological writings of Germany.

Freisleben cites from an author (Karsten) who classes the coal and rotheliegende together as subordinate members of one great sandstone formation, the following enumeration of the several beds included by him in that formation, taken in an ascending order. 1. Conglomerate of ancient rocks. 2. Siliceous conglomerate. 3 to 8. Coal sandstone and shale. 9. Trap rocks. 10. Clay ironstone. 11. Rotheliegende. 12. Weissliegende. Now if we look among these rocks for the representative of our own old red sandstone, it must be sought in Numbers 1 and 2, not in Number 11.

in any part of the island displayed, inasmuch as all the beds of that formation come indifferently into contact with the superstrata. It is possible that were those highest beds visible, they might be found to exhibit a gradual transition (as is the case in so many other instances) into the characters of the next sandstone series. If we are to refer the rotheliegende to the coal formation in any manner, it can only be in considering it as thus intermediate in place and character between the regular coal measures and the sandstones of the next æra. *To identify it in any way with the lowest beds of the whole system is to invert every foundation of geological arrangement, and to unsettle all those principles to which the science owes its present precision.*

Distribution of the Carboniferous Series.

(A.) *Coasts of the Baltic.*

Following the same course which was pursued in indicating the distribution of the ancient chains, we may first trace the coal formation, where it appears to rest against the most northerly of these chains, that of Scandinavia.

In this line, we find coal in the island of Bornholm, and again in Sweden on the south of the primitive tract near Helsingborg, at the mouth of the Baltic.

(B.) *Scotland.*

If we regard the Grampian mountains as a prolongation of the Scandinavian chains, the great coal district of Scotland must also be considered as similarly related to those above-mentioned. It occupies the tract forming what may be called the great central valley of Scotland (speaking relatively, for considered in itself its surface is very considerably varied), which lies between the great transition chain on the south, and the still loftier primitive ranges of the highlands on the north. The whole of this wide tract is occupied by the coal measures, the carboniferous limestone, and the old red sandstone, associated in every possible manner with vast accumulations of every variety of trap.

In the low district on the east of Sutherland, where the secondary formations again intrude among the primitive highland chains, coal has been discovered at Brora; but from the slight description incidentally given of this tract in the memoir of Mr. Bald (vol. iii. Trans. Wern. Soc.), before referred to, it may be conjectured that this does not belong to the principal coal formation, but to those beds which occasionally occur in more recent formations, being, perhaps, of the same æra with the coal of the Cleaveland district in Yorkshire.

In Dumfrieshire, near the southern or transition chain of Scotland, we find many limited coal-fields reposing against, or forming narrow basins in, the valleys of the latter chain; these are associated with, and rest upon as usual, thick beds of the carboniferous limestone.

Trap rocks (porphyry, greenstone, basalt, &c.) occur extensively associated with and overlying the coal districts of Scotland.

(C.) *Ireland.*

We shall next proceed to Ireland, postponing the enumeration for the present of the English coal districts; because the former country is more immediately connected in its geological relations with Scotland.

As we have already traced the primitive and transition chains from the south-west of Scotland to the north-east of Ireland, the formations of the great central valley of Scotland here likewise intervene, and among them the coal measures, which may be seen emerging from beneath the overlying basalt at Fairhead on the north-east, and again just beyond the south-west of the basaltic area at Coal Island and Duncannon; but other parts of Ireland present far more important coal districts. Indeed the island may generally be described (with the exception of the north-east basaltic area) as being almost surrounded with a series of primitive and transition groups, including a great central area entirely occupied by the old red sandstone, carboniferous lime, and coal measures. The structure of these districts very closely corresponds with the tracts of the same formation in England.

The coal district already mentioned is termed by Mr. Griffiths the Ulster coal district. There are three other principal coal fields.

2. The Connaught coal district occupies an extensive tract, in the centre of which Lough Allen is placed.

3. The Leinster coal district is situated in the counties of Kilkenny, Queen's county, and county of Carlow. It also extends a short distance into the county of Tipperary, as far as Killenaule. This is the principal carbonaceous coal district. It is divided into three detached parts, separated from each other by the carboniferous limestone, which not only envelopes, but in continuation passes under, the whole of the coal district.

4. The Munster coal district occupies a considerable portion of the counties of Limerick and Kerry, and a large part of the county of Cork. It is by much the most extensive in Ireland; but as yet there is not sufficient information respecting the number, extent, or thickness, of the beds of coal it may contain.

(D.) *England.*

The coal fields of England will, from geographical position, naturally fall under the following arrangement: 1. The great northern district, including all the coal fields north of Trent. 2. The central district, including Leicester, Warwick, Stafford, and Shropshire. 3. The Western district, which may be subdivided into North-western, including North Wales, and the South-western, including South Wales, Gloucester, and Somersetshire.

Physical circumstances also confirm this geographical arrangement.

1. *The Northern District.*—A chain of hills, denominated in the time of the Roman colonists of Britain the Penine Alps, forms a continuous ridge (locally, I believe, called the back lope of England), through the northern counties, from Northumberland to Derbyshire. At its northern and southern extremities (that is to say, in Northumberland, and the West Riding of Yorkshire, and in Derbyshire), this chain exhibits the carboniferous limestone (No. 3 of the carboniferous series). All other parts of it are composed of the shale and grit (No. 2); round the sides of this chain the regular coal measures (No. 1) are disposed so as to constitute several distinct fields.

These may be enumerated in the following order: (*a*) The great coal field of Northumberland and Durham. (*b*) Some small detached coal fields in the north of Yorkshire. (*c*) The great coal field of South Yorkshire, Nottingham, and Derby. On the south, we find only (*d*) some successful trials for coal in the neighbourhood of Ashborne, which have, however, never been further prosecuted. On the west (*e*) the coal field of North Stafford. (*f*) The great Manchester, or South Lancashire coal field. (*g*) The North Lancashire coal field. (*h*) The Whitehaven coal field; between this and the preceding coal field, the transition mountains of Cumberland rise on the western side of the Penine chain, but a zone of carboniferous limestone is detached from the Penine chain, and mantles round this group. On the north-west of this zone, the last mentioned coal field reposes. (*i*) The indications of coal at the foot of the western escarpment of Cross Fell.

2. *The Central Coal Districts* include four detached fields emerging from beneath the great plain of new red sandstone covering our midland counties.

a. Ashby de la Zouch. *b.* Warwickshire, between Atherston and Nuneaton. *c.* South Stafford, round Dudley: the coal measures here repose on the transition limestone, Nos. 2, 3, 4, being here deficient. *d.* Indications of coal near the foot of the Tickey Hill; also in contact with transition limestone.

3. *Western Districts*, subdivided into

a. North Western, including, 1. A trough of coal measures reposing on carboniferous limestone traversing the town of Anglesea. 2. A coal field resting on the same rock in Flintshire; the carboniferous limestone range continuously on the north of the transition mountains of North Wales.

b. Middle Western, or Shropshire.—This includes several detached fields. 1. In the plain of Shrewsbury. 2. In Coalbrook dale (this reposes on transition limestone). 3. On the summits of the Clee Hills, and in South Shropshire. 4. Near the Abberley Hills (resting on transition limestone).

c. South Western.—This includes three principal basins occu-

pied by the coal measures, and surrounded by zones of carboniferous limestone, the whole reposing on one vast tract of old red sandstone. Of these basins, the largest is situated in South Wales, and occupies the greater part of Glamorganshire, extending into Monmouthshire on the east, and Caermarthen and Pembrokeshire on the west. The next in importance occupies the south of Gloucester, and the north of Somersetshire. It is particularly interesting to the geologist, because the more recent formations sweep over a part of it; and their relations with the coal series may here be ascertained by actual sections. Coal shafts being sunk even from the lower oolite through the lias and new red sandstone into the coal measures. The third basin in point of extent is intermediate in position between the other two occupying the forest of Dean, between the Severn and the Wye.

Trap rocks (principally basalt, greenstone, and amygdaloid), are associated with and overlie many of these districts, especially those of Northumberland, Staffordshire, and Shropshire.

(E.) *France.*

As we have already traced coal fields in the north of Europe, apparently connected with the central system of Scotland, so we might naturally look for the resumption of those of the south-western English counties in the opposite regions of France. It is true, indeed, that in the south of Somerset and through Devonshire, no coal has been observed; being probably concealed by the advance of the overlying deposits of new red sandstone which are there in close contact with the transition chains. These transition chains cross, as is well known, from Devon to the peninsula of the Cotentin in Brittany; and we find, as might be expected, a small coal field reposing against their eastern side at Litry on the south-west of Bayeux; further south, where the Loire enters between the continuation of these chains, between Angers and Nantes, are more extensive deposits of this formation.

In the centre and south of France, there are some limited coal deposits lying in the valleys of the Loire, the Allier, the Creuse, and the Dordogne, the Aveyron and the Ardeche between ridges proceeding from the primitive central group connected with the Cevennes, and also on the south-east between the Cevennes and the Rhone.

Several particulars concerning some of these districts may be found in the account of the geological speculations of Mr. Rouelle in the first volume of the Geographie Physique, forming part of the great Encyclopedie Methodique; the Annales des Mines for 1821 contains some information concerning of those near St. Etienne, department of the Loire, and a full account of those of the Aveyron.

From the south of France we may proceed to Spain, which could not so conveniently be included in any other part of our survey. Coal is here mentioned as occurring in eight places in

Catalonia, in three in Arragon, and one in New Castile; but no particulars are given: a list of these localities may be found in Laborde's view of that country.

(F.) *Northern France, the Netherlands, and adjacent Parts of Germany.*

A great carboniferous tract occupies these countries.

It may generally be described as extending westwards from Hardinghen near Boulogne (only a few miles from the coast of the channel) by Valenciennes, and thence up the Scheldt and down the Meuse to Eschweiler beyond Aix la Chapelle; and still further west, many of the coal districts of Northern Germany may with great probability be considered as a prolongation of it.

On the east and north, the great deposits of chalk and the strata above the chalk, skirt and partially (particularly within the limits of France) overlie this tract. On the south, it is bounded by the transition ridges (of slate, greywacke, &c.) which occupy the forest of Ardennes, overhang the magnificent defile of the Rhine from Bingen to Bonn, and thence extend to the Westerwald. This tract does not consist of a single continuous coal field, but of many insulated and basin-shaped deposits of this formation, encircled by carboniferous limestone and old red sandstone. In many respects it bears, even down to the character of its picturesque scenery, a remarkable analogy to the coal districts (likewise consisting of many insulated basins) in the south-west of England.

We find the most westerly point of this extended chain of coal fields at Hardinghen, in the great denudation exposing the beds beneath the chalk, which comprises the Boulonnais on the French side of the channel, and the Weald of Kent and Sussex on the English; of this we have before given a general description. These coal mines, and the quarries of the carboniferous limestone associated with them, which appear at Marquise, are situated at the very foot of the escarpment of the environing zone of chalk hills; for the outcrop of all the intermediate formations crosses this part of the denudation to the south, and, as it were, withdraws to expose the coal; proceeding westwards, the coal is worked at several places within the general limits of the overlying chalk-formation. The environs of Aniche near Douay, and of Monchy le preux near Arras, present deposits of this nature; the mines surrounding Valenciennes are still more extensive.

In the environs of Mons, Charleroy, and Namur, in a tract surrounding Liege; and lastly close to Eschweiler on the east of Aix la Chapelle, other very considerable coal fields are worked.

A general account of this line of coal formation may be found in Omalius d'Halloy Geologie du Nord de la France, Journal des Mines, and in Von Raumer's Geognostich Versuche; many

interesting details are also given in Villefosse sur la richesse minerale (tom. ii. p. 432 & seq.) and illustrated in the magnificent atlas of that work by sections exhibiting the contortions, &c. of the beds, and the mode of working them, from Pl. 25 to 27.

Proceeding still further along the northern border of the same transition chain, against which all these deposits of coal repose, we find the more recent formations (probably of the tertiary class) intruding upon it, and concealing the coal till we cross the Rhine near Bonn. On the right bank of that river, these again recede to the north, and in this direction we again find an extensive coal field proceeding along the small river Ruhr a little above its junction with the Rhine: on the south the beds of this coal field describe the segment of a circle, cropping out against alternations of limestone, shale, and what is called greywacke (our old red sandstone probably), which separate them from the regular transition slate: on the north they are bounded by the overlying and more recent deposits. An account and plans of this district may be found in Villefosse, tom. ii. p. 424, and Pl. 24.

A little on the south of the same district of transition rocks, whose northern border we have been hitherto pursuing, limited coal fields occur in the country between the Moselle and Rhine; first, between Sarrebruck and Sarre Louis on the river Sarre, and, secondly, near Waldmohr on the banks of the Glane, extending to its confluence with the Nahe: the beds of the former coal field are described as ranging south-west and north-east, and dipping north-west; they are covered with red sandstone, and also surrounded by the same formation on the points to which they rise, appearing, therefore, to repose upon it; but these appearances are very vaguely described; "sur ces grès rouges semblent quelquefois s'appuyer les conches de houille;" they are probably deceptive. A careful examination of the country between this coal field and the northern transition chain is necessary to ascertain its true relations. Villefosse, tom. ii. p. 447, and Pl. 27, may be consulted on this district.

Keferstein has given a brief but very clear description of this porphyry and coal district, extending on the south of the slate mountains between the Rhine and the Moselle by Zweybruck and Sarrebruck (Teutschland, &c. p. 81, No. 1).

He describes the coal measures, exhibiting the ordinary members and characters of this formation as extending between Sarrebruck and Neukirch; they contain some alternating beds of carboniferous limestone. The stratification is extremely contorted and dislocated; masses of unstratified trap rocks (comprising porphyrywacke, amygdaloid, greenstone, and basalt), are interposed among the coal measures. Agates abound in the amygdaloid.

Quicksilver occurs both in the porphyritic conglomerate, and in the coal sandstone.

"The *red sandstone* (by this term, Keferstein always denotes the rothetodteliegende as distinguished from the bunte sandstein), *lies in several places on these formations.*"

(G.) *Coal near the Vosges.*

Coal occurs on the west side of the Vosges, but I am not acquainted with any particular description of this tract.

(H.) *Coal of the Alps.*

Traces of the coal formation are rare in this mountain range; but such have been observed in some parts of it.

M. de la Beche thus notices one remarkable instance of this kind:

"The Col de Balme, which closes the valley of Chamouny to the north-east, and separates Savoy from Switzerland, has long been known for the superb view which it commands of the valley of Chamouny, with the Mont Blanc range in one direction, and the mountains of the Valais on the other. The iron cross on the highest part of the Col, or passage, is, according to M. de Saussure, 7086 French feet ($7558\frac{6}{10}$ English feet) above the level of the sea. The Col is composed of beds of clayslate, of limestone, and of a few thin beds of sandstone. The rocks of the Col de Balme have been called primitive by M. Ebel, in his Bau der Erde en dem Alpen-Gebirge, but were with more justice named secondary by M. de Saussure. The beds which compose them seem to be a continuation of limestones, which are remarked in patches in the valley of Chamouny, and which probably once occupied the whole length of the valley.

"While crossing the Col de Balme, in the autumn of 1819, I picked up two portions of the thin beds of sandstone abovementioned, which I found to contain vegetable impressions precisely similar to what have been termed coal plants, because they are usually found in coal formations. But I tried in vain to find these fossil plants *in situ*, many parts of the Col being too precipitous to allow of my approaching them."

From further conversation on the subject with M. de la Beche, I am persuaded that this spot presents a trough of nearly vertical beds belonging to the true coal formation squeezed in, as it were, between the primitive ridges.

Keferstein notices traces of coal associated with porphyry on the south side of the Alps near Botso. Humboldt also notices these coal deposits: they are on the banks of the Adige between Sais and St. Peter.

(I.) *Coal of Osnabruck.*

Pursuing the line of Northern Germany, a tract containing

coal appears to range many miles on the south-west and south of Hanover between Osnabruck and Hildesheim, but we cannot refer to any description of it; it may probably form the prolongation of the northern line of coal fields which we lately traced as far as the Ruhr.

(K.) *Coal and Porphyry Formations surrounding the Hartz.**

These associated formations succeed to the slate mountains of the Hartz, near the east end of which they present themselves in three points:

1. The Opperode district.
2. The Ilefield district.
3. The Petersbirge district.

Both the first *lie immediately on the slate,* and form a portion of the Hartz chains. The third forms an insulated district in the Saale kreisse. The coal formation presents the ordinary alternations of bituminous shale and coal sandstone, of the usual varieties, and some calcareous beds with marine fossils. Three beds of coal are sometimes found; the principal variety is slate coal.

1. Near Opperode (on the north-east of the Hartz), the coal *lies under,* and in part† also in the red sandstone; no porphyry is found in this tract.

2. But in the Ilefield district‡ (on the south-east of the Hartz), porphyry prevails near Neustadt. The *more ancient members* of this formation pass immediately into the greywacke through modifications approaching to hornstone rocks. The *younger members* are mixed with more clay, become sandy and conglomerated, and thus *pass into the red sandstone. The coal strata lie between the porphyry and the slate hills, so that they have the first place in the order of superposition* (sie ersten zum hangenden haben). *In the upper formations, the conglomerates and sandstones exhibit themselves.*

3. The Petersbirge. This is a great mass of the porphyry formation bounded by Lobegun, Wettin, Halle, Landsberg, Bitterfield, and Zorbig (lying a few leagues south-east from the Hartz).

* I have abridged (but without any other alteration than that of condensation) this account from Keferstein (Teutschland, p. 138, No. 1). I have done this because the statements I formerly published have been controverted by Mr. Weaver. It is well, therefore, to call in an impartial witness as arbitrator. I must leave the reader to judge towards which side the evidence thus introduced inclines.

† This is the part which Freisleben separates from the true coal formation; it extends to Meisdorf and Endorf, and is coloured in the map accompanying his work as rothetodte; but that map exhibits also the true coal formation as here interposed between the rothetodte and the transition rocks.

‡ The true coal formation lies (see the map accompany Freisleben) considerably on the north of Neustadt. The coal beds described by him as subordinate to the rothetodte are on the contrary on the south-east of that town, extending thence towards Ilefield. The whole of this tract is coloured as rothetodte in the map, which presents the regular series; transition rocks, coal, porphyry, rothetodte, overlying each other in succession.

Porphyry is the prevalent rock; the *upper* beds (as at Neustadt) become conglomerated and approximate to the red sandstone.

The coal measures occur at Lobegun, Wettin, Dolau, Brachwich, and Giebicenstein; they occur in the porphyry, sometimes covering, sometimes covered by it (the map accompanying Freisleben represents them as generally beneath the porphyry); the porphyry *above* and below the coal are distinguished by the more granular structure of the former, which is associated with the conglomerates; the coal is stratified, but disposed in saddles, troughs, &c. and often swells into irregular masses. Where the coal measures are thickest, and no porphyry is found beneath them (as at Wettin), the coal sandstone prevails to the greatest depth, and is often much like the greywacke.

The red sandstone lies either upon the slate mountains of the Hartz,* or *upon the porphyry of Ilefield and the Petersbirge,* and forms a range of hills stretching through Mansfield between the two points.†

With regard to the porphyry associated in these coal districts, I have to add to the above account, that its relations with the formations among which it occurs are very obscure. Humboldt

* That is where the porphyry and coal are wanting, as appears from the remainder of the sentence. See also the map in Freisleben.

† It appears from the statement of Freisleben, that the rothetodte of these hills *reposes upon the Wettin coal field.* His localities include *all the rothetodte* represented by the map accompanying his work in that quarter; so that the fact of the superposition of the *great mass of the rothetodte* above that coal field cannot admit a doubt. It appears, however, that a conglomerate resembling the rothetodte also occurs in some places beneath these coal measures. On this account, Freisleben is inclined to rank this field, not with the true coal formation, but with the carbonaceous beds subordinate to the rothetodte. His inferences are, however, open to doubt, first, because, he says, *he had never himself seen the inferior conglomerate in situ, and reasoned from specimens only;* and, secondly, because the occurrence of conglomerates of similar character above and below the coal measures can never be admitted as a proof of identity of formation, otherwise our own conglomerates of the old and the new red sandstone must be considered as a single formation, and the carboniferous limestone and coal measures be treated as subordinate to that formation—a conclusion which, in the mind of every instructed geologist, will be fully equivalent to a *reductio ad absurdum.* I, therefore, demur to the statement that any part of these coal districts are really subordinate to the rothesandstein, as one requiring further confirmation. Be this as it may, however, it will not prove that the true coal formation (*which, as we have seen, is distinct from these subordinate beds*), is similarly related. The whole evidence shows, as clearly as any evidence can do, that *the appearance of this rock is confined to the upper regions of the coal formation;* and if it be not referable, as (following Buckland), I believe it to be, to the sandstone series of the succeeding geological æra (with which I again assert, *from personal examination,* and not with our old red sandstone, it most closely agrees), it can only be considered as an upper member in the coal series. Humboldt inclines to consider the red sandstone as associated with the coal series: *La houille,* he adds, *paroit le plus souvent au dessous du gres rouge, quelquefois il est placée evidemment ou dans cette roche ou dans la porphyrie.* He adds no other facts than these above alluded to; and I, therefore, adhere to the interpretation before given of the cases in which it is said to occur in the red sandstone.

In concluding this note, I have to correct an error which has arisen from hasty transcription in Mr. Weaver's account of the beds in the Lobegun colliery: he makes the lowest stratum rothetodteliegende, whereas it stands in his original rothethonartigerliegende; not the *rothetodte,* but a red argillaceous stratum. The point is not very material; because Freisleben probably considered it as belonging to that formation; but questions of this kind can only be settled by minute accuracy.

observes that it penetrates the coal measures in various manners; sometimes it covers the coal immediately; more generally it reposes on the sandstone, elevating itself above this rock in domes, towers, and escarped rocks. When the transition rocks are immediately covered by the red sandstone, it is difficult to say whether the porphyry associated with the coal is referable to the transition or sandstone series. The porphyry seldom forms true beds in the coal measures, but rather transversal and interposed masses. He adds, that these masses offer many analogies with volcanic rocks, and inclines to favour the opinion, that the pretended passage of the porphyry into the sandstone is an illusion produced by regenerated porphyrics; i. e. by the subsequent reunion of porphyritic debris. These remarks are applicable generally to the porphyry associated in the coal districts of Germany. From its intimate connexion in geographical position with the coal districts, I have included it under the same colour, though strongly inclined to consider it as of subsequent formation.

(L.) *Coal and Porphyry of the Thuringerwalde.**

The porphyry of the Thuringerwalde constitutes the highest portion of that chain; it contains, according to Keferstein, subordinate beds of coal between Ilmenau and Sahl.

(M.) *Coal, &c. on the Western Borders of the Chains extending from the Thuringerwalde.*

A small coal district occurs on the borders of the Saxon slate mountains, not far from Steinach, near the point where they join the Fichtelgebirge, and porphyry is found on the borders of the Bohemerwald, near Ratisbon.

(N.) *Great Saxon District of Coal and Porphyry.*

This is an extensive district which may generally be described as lying along the course of the Zwickau between Leipzig and the Erzegebirge; porphyry prevails. Coal accompanied by the usual rocks occurs near Zwickau, at Schonfield, Planenschen grund near Tharand, &c. sometimes overlying, sometimes underlying, and sometimes associated with the porphyry.† This dis-

* The following articles are chiefly from Keferstein.

† At Schonfeld, the coal alternates with porphyry, above which occur the following beds: 1. A conglomerate of porphyry and gneiss. 2. Bituminous shale with vegetable impressions. 3. Red sand. At Zwickau the beds (beginning with the lowest), 1. Wacke. 2. Basalt. 3. Nine or ten coal beds alternating with white grit and shale containing vegetable impressions. 4. Sandstone. 5. Red grit. The coal field of Planeschen grund is more extensive than either of the former; here a range of sienite, extending on the right bank of the Weisseritz, forms the fundamental rock on which a secondary porphyry reposes; then succeed four beds of coal alternating with grit and shale, and inclined at an angle of 65°.

There is no bitumen in the coal of Schonfeld; although it abounds at Planeschen grund: the same fossil vegetation is presented in all these mines. (See Sternberg 'Flora zur Vorwelt.')

trict is supposed to have a subterraneous connexion with that of Petersbirge near the Hartz.

(O.) *Coal and Porphyry of Bohemia, and Bohemian Silesia.*

A zone of these formations crosses these countries from south-west to north-east. It may be thus subdivided:

1. *The Pilsen Coal District.*—A series of detached coal basins reposing on transition slate, extending from Merklin, by Pilsen and Radnitz, to Prague. Porphyry does not occur in this tract.

2. *The Waldenburg District.*—Extending from Landshut to Waldenburg and Glatz between the Riesengebirge and Eulengebirge. It exhibits both porphyry and coal.* These formations alternate; a chain of them follows the slate mountains; *then succeeds the red sandstone.* The coal is very irregular in its stratification; the principal variety is slate coal, the ordinary coal rocks occur: the beds are numerous.

3. *The Pilsen and Waldenburg Districts* have evidently a subterraneous communication beneath the intermediate plains in which the coal formation often makes its appearance. No porphyry is seen at these points.

4. *At Freiheit Semile and Liebenau,* the porphyry alone appears.

(P.) *Moravian Coal District.*

Coal, unaccompanied by porphyry, occurs in the environs of Brunn.

(Q.) *Upper Silesian Porphyry and Coal District.*

This is an extensive district including the following towns: Pless, Freystadt, Troppau, Iagerndorf, Kosel. It lies partly in Silesia, and partly in Poland: in the former, it exhibits coal only; in the latter, coal and porphyry. The coal formation reposes immediately on the slate mountains of the Sudetengebirge. The strata are elevated in approaching that chain, but more horizontal as they recede from it. The coal measures are covered by the porphyry, which, in its turn, supports the Alpine (magnesian) limestone. The coal measures pass by such a gradual transition into the greywacke on which they repose, that, according to Keferstein, it is difficult to ascertain the exact demarcation between them. The usual rocks of the coal formation prevent grits of various textures; *millstone grit*, shale, with

* According to the map and sections of Von Raumer, the outcrop of the principal coal beds follows the border of the transition rocks; but this writer mentions a conglomerate and a limestone among the upper beds of the transition series; and as he (in common with Beudant, Humboldt, Daubuisson, &c.) always refers the old red sandstone and mountain limestone of English geologists to the transition class, he very possibly thus designates them here. The same map and sections show that a great part of the porphyry and the *red sandstone generally are placed above the great coal formation.* But he adduces instances of coal subordinate to the red sandstone, and inclines to consider them as referable to one great formation.

nodules of clay ironstone, and (carboniferous) limestone; the coal is mostly slate coal: there are numerous beds, and some of very considerable thickness.

(R.) *Coal of Hungary.*

The lower series of our coal formations; that is to say, our old red sandstone and mountain limestone, are expressly, and by name, recognised by Beudant, as reposing on both sides the Tatra and Kralova mountains (a portion of the Carpathian chain): he refers them to the transition class, and describes them as grit of a red or white colour, having a siliceous cement supporting a compact limestone with nodules of chert. On these repose the coarser coal grits; then some beds associated with limestone, and also containing traces of coal (which, however, from his description, I should rather refer to the rothetodte series); then amygdaloid and red grit; and, lastly, the saliferous sandstone. Coal is found at Balligorod and Rosocky, near Sanok.

Another coal district occurs at Funfkirchen, on the borders of Sclavonia; it presents (beginning with the fundamental rock), 1. Black limestone. 2. Coarse coal grit. 3. Slaty coal grit. 4. Shale and fetid limestone. 5. Carbonaceous grit. 6. Coal. 7. Several varieties of grit. 8. Greenstone. 9. Red grit. 10. Red porphyry. The latter beds clearly belong to the rothetodte of Germany.

(S.) *Coal of Russia.*

Coal or other bituminous formations are represented by Mr. Strangways as occurring, 1. In the north of Russia near Yarousk. 2. On the east reposing against the Ural mountains, near the source of the Chusovaga. 3. In the centre of Russia, at Calouga and Toula (where the great iron works are established). 4. In the south, at Bakmont on the Donetz. 5. In the Crimea, and reposing against the Caucasian chain; but these districts have not yet been examined with sufficient care to ascertain whether the beds really belong to the true coal formation.

(*To be continued.*)

Article X.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

Dec. 19.—A paper was read, On the Chinese Year, by J. F. Davis, Esq. FRS. The introductory portion of this paper was occupied, in proving that no scientific knowledge of astronomy existed in China prior to that which was introduced in early

times by the Arabians, and afterwards by the European missionaries. The 36 eclipses recorded by Confucius, are useful in determining points of chronology, but furnish no evidence of astronomical *science;* the Chinese had been in all ages attentive observers of the sky, and of the apparent changes of the heavenly bodies. The encouragement and promotion by that ever-jealous people, of foreign professors of astronomy, evince that they could not, originally, have been acquainted with it themselves; and this is also shown by their adoption of the errors of those foreign professors. The author has seen in an ancient Chinese book, a complete delineation of the Ptolemaic system, with its crystalline orbs, and the earth in the centre. The inscriptions in the Chinese language on some of their ancient instruments, do not prove their own knowledge of astronomy; those instruments were made for them by the Arabians: the cannon cast for the Chinese by Europeans have inscriptions on them in the language of the former.

It has ever been the ungrateful practice of that people to appropriate as their own every invention of other nations. When Mr. Pearson transmitted to China some of the vaccine matter, he sent with it a pamphlet in Chinese, containing directions for its use; an expurgated edition of this was published, shortly after its arrival, in which nothing appeared, from which it could be learned that vaccination was not a Chinese discovery.

The nature of Mr. Davis's astronomical details concerning the Chinese year, precludes us from giving an account of them; they were accompanied by an illustrative drawing, showing the 28 constellations of which the year consists, with the degrees they respectively occupy: the Chinese have no solar year.

At the same meeting a portion of the following paper was read: —On Rocks that contain Magnesia, by Charles Daubeny, MD. MGS. Professor of Chemistry, Oxford: communicated by Prof. Buckland; after which the Society adjourned over the Christmas vacation until Jan. 9, 1823.

Jan. 9, 1823.—The reading of Prof. Daubeny's paper was resumed and concluded. This paper commenced with an account of the localities of the secondary magnesian rocks in England and on the continent of Europe. The presence of magnesia in many simple minerals, and in the primary strata, had long been well known; but Mr. Tennant was the first to detect its presence in certain secondary limestones, which occupy a considerable space in the north of England; and corresponding magnesian beds have since been discovered to exist extensively on the continent. This earth appears to extend almost throughout the secondary strata: it occurs in the mountain or carboniferous lime series; in the zechstein of the Alps, referred by Prof. Buckland to the English magnesian limestone; it has been found by Mr. Warburton in the blue and in the white lias, and its presence in them is indicated by the springs containing sulphate of magnesia with which they abound. The presence of

this earth in the oolites has not been ascertained with certainty, and it has not yet been discovered in the chalk of this country; though Brongniart has detected it in that near Paris; and he ascribes the sterility of Champagne, to its presence in the chalk of that province. Magnesia also occurs in the tertiary formations which, in many countries, succeed the chalk; its presence in the London clay is shown by the efflorescence of its sulphate from the bricks which are made of it, and the springs of Epsom may also be adduced in proof of this: it has likewise been found in the calcaire grossier of France, and in a specimen of the same formation containing nummulites, from near Verona.

After some remarks on the importance of the subject, in its connexion with building and with agriculture, from the modification by the magnesia of the characters of the rocks into which it enters, and from the effect of that earth upon vegetation; Dr. D. proceeded to describe the chemical methods he employed in his examination of the magnesian rocks. He stated that our object be merely to detect the *presence* of magnesia in a limestone, we may adopt Dr. Wollaston's process, by carbonate of ammonia and phosphate of soda; or that in which oxalate of ammonia is used in conjunction with those salts; but these cannot be employed in ascertaining the *quantity* of it which may exist; for in both of them a portion of magnesia is thrown down; and in the first, a part of the lime remains unprecipitated. For the last mentioned purpose, Dr. D. suggested the following process, for the details of which he referred to his paper on the subject lately published in the Edinburgh Philosophical Journal. Dissolve the substance under examination in nitric acid, evaporate the solution to dryness, so as to expel the nitric acid; then dissolve the lime and magnesia in acetic acid, and separate them by converting them into sulphates: the only objection to this method of separating the two earths is, that by too great a heat, part of the acid may be driven off from the sulphate of magnesia, and so the proportion of that earth underrated; or, in consequence of not employing sufficient heat, some water may remain in the salt, and thus the quantity of magnesia may be overrated.

The paper concluded with a catalogue of the secondary rocks in which the author has found magnesia, with some account of their external characters; the primitive rocks were omitted because the presence in them of the earth in question is so well known. Some of the characters of magnesian limestones afford a presumption of their nature; their colour varies from honey-yellow to saffron-red, and their fracture presents small crystalline points, having a glimmering lustre: slight effervescence with acids, of course, is a test only when the proportion of magnesia is large; but it is a sufficiently accurate one for agricultural purposes.

At this meeting likewise, the following paper was read:—Corrections applied to the great Meridional Arc extending from Latitude 8° 9′ 38·39″, to Latitude 18° 3′ 23·64″ to reduce it

to the Parliamentary Standard, by Lieut.-Col. William Lambton, FRS. In this paper, Col. Lambton expressed his satisfaction, on account of the uniformity thereby obtained, that the commissioners appointed to consider the subject of weights and measures have adopted Mr. Bird's standard. In order to reduce the above arc to this standard, the measurement of it determined by the brass scale must be multiplied by ·0000018, and the product *subtracted* for the correction; and that by Ramsden's bar must be multiplied by ·000007, the product being *added* for the correction. Col. Lambton has just completed some measurements, which, when the requisite calculations are made, he purposes to submit to the Royal Society. He is proceeding with his arc through Hindostan; if Scindiah's country continue quiet, a section of it will pass through Gwalior, his capital, and end at Agra on the Jumnah.

Jan. 16.—Some practical Observations on the Communication and Concentration of the Magnetic Influence, by Mr. J. H. Abraham, of Sheffield; communicated by the President. This paper was divided into three sections; the first being on the depth to which magnetism penetrates. In this, the author stated, as the result of a number of experiments with steel bars of various dimensions, that magnetism does not penetrate deeper than the 1-20th of an inch; and that bars of 1-10th of an inch thick are as powerful as those of greater thickness, the increase of surface in the latter being taken into consideration. The second section related to the communication of the magnetic influence: in this, some minute directions were given for the formation of magnets of the bar and horse-shoe kinds, both simple and compound; the construction of a very powerful compound magnet in the author's possession was explained by means of a drawing. It was stated that magnetism, like electricity, extends at once over the whole surface of the body exposed to its influence. If an octagonal bar of steel be magnetized by a stroke with a set of magnet-bars along one of its sides, each side, at the same distance from the centre, will acquire the same degree of magnetic power. In another respect, however, magnetism differs from electricity in a striking manner: if a charged Leyden jar be brought into contact with one that is not charged, the electric fluid will be immediately communicated to the latter, and it will be divided between the two in an equal proportion; but one bar of steel being placed upon another, though the uppermost become magnetized over its whole surface instantaneously by a single stroke with a set of magnets, yet the lower one did not acquire sufficient magnetic power for the attraction even of needle pointings, which are much finer than iron filings. It was the observation of the magnetic action on these pointings, that led the author to his invention for obviating the ill effects of dry grinding, which the Society of Arts had crowned with their gold medal. In the last section of the paper, some phænomena in polarity were described. The author has succeeded in giving

several poles to a magnet by the following method: he took a set of magnets, and went over a bar with them in one direction, from one end to the middle, then turning the set round went on from the middle to the other end, thus leaving off with the same pole that he began with: the bar so magnetized possessed similar poles at the ends, and exhibited opposite polarity in the middle: in this manner even five poles may be given to a single bar of steel.

At the same meeting, the reading was commenced, of Observations on Magnetism, by John Macdonald, Esq. FRS.

LINNEAN SOCIETY.

Jan. 21, 1823.—The following papers were read:—Description of three Insects of Nepaul, by Major-Gen. T. Hardwicke, FLS.

Description of a Tail-less Deer, Native of the Snowy Mountains of Nepaul, by the Same.

Perhaps the *Cervus pygargus* of Pallas: head the size of that of a full-grown stag; horns trifurcate, tuberculated at the base; neck curved, like that of a camel, with a mane on the back; when walking, carries its head in a horizontal position. Though called tail-less, it has the thick rudiment of a tail, four or five inches long. Colour, a brownish ash-colour; darkest along the dorsal line. The following are some of the dimensions of the specimen examined, which was presented by the Court of Catmandu to the British resident, and is now in the menagerie of the Marquis of Hastings, in his park at Barrackpore. Length of head 1 foot 5 inches, ditto of neck 3 feet 5 inches, ditto of body 2 feet 5 inches, total length 7 feet 3 inches; height 4 feet 3 inches, circumference round the abdomen 4 feet 9 inches. Though the animal has been accustomed to the society of man for two years, yet it still brings its horns into a position of offence or defence when approached; it is not, however, fierce; but may easily be led by the horns.

GEOLOGICAL SOCIETY.

Nov. 1 *and* 15.—A paper was read "On the Geology of Hungary," by the Hon. W. T. H. Fox Strangways, MGS.

The author, after stating that *calcaire grossier* is found in the immediate vicinity of Vienna, follows the course of the Danube, and enters near Presburg, the lesser plain of Hungary; this plain is bounded on the west by the hills called Leitha Guberge, and a granitic chain, which is connected with the White Hills and the Carpathians. These ranges form the gorge of the Danube at Presburg; on the south is a branch of the Alps of Styria and Carinthia; on the north are the ramifications of the northern part of the Carpathians; on the east, the hills of the forest of Bakony, through a gorge of which, between Gran and Buda, the Danube finds its way into the great central plain of

Hungary. The author supposes the whole of the lesser plain of Hungary to be composed of calcaire grossier, and the several localities in which he observed it are enumerated; leaving this plain, and proceeding northwards, he crossed the granitic chain which lies between the valleys of Nyitra and Thurocz, and continuing his route, ascended Mount Fatra, the lower part of which is composed of shale, above which is a hard oolitic limestone which the author believes to be only the lower bed of the calcaire grossier.

On the right bank of the Vag, opposite the town of Rosenberg, are some conical hills of hard white calcaire grossier, on a rock of which is the ruined castle of Dyömbir. This rock continues to form all the hills on the right bank of the river, and behind them are seen the high summits of the Carpathians, among which the conical Mount Tepla is most conspicuous. The calcaire grossier during all this space resembles that which forms the left bank of the Danube between Ratisbon and Passau. Before arriving at Ocholicsna, the beds of calcaire grossier terminate on the north side of the valley, throwing up a bold escarpment towards the magnificent group called collectively the Mount Tatra, and of which the Krivan (esteemed the loftiest of the Carpathian chain), rising into the form of a cone, forms the western extremity.

Most of the high valleys in the north of Hungary are poor and ill cultivated; bare of wood, except a few stunted pines. Continuing his route eastward, Mr. Strangways found the country to consist chiefly of shale and grit, which extends nearly as far as the neighbourhood of Eperies. On the road to Bartpha, it is interrupted by a narrow band of a dark porphyritic granite, which rises into detached conical hills near the post Ternyo. On the westernmost is situated the fortified town of Szeben. Near the town of Bartpha is a reddish shale and sandstone, which constitute the mass of the continuous range of the Carpathians. Crossing this range by the pass of Dukla, he entered by the valley of the San, the vast plains of Poland, highly cultivated, and in every way a contrast to the poor, but varied mountains of Hungary. Gallicia is a plain of vast extent; in this rich but uniform country, natural sections and interesting scenery are found alone on the banks of the rivers. The whole country appears to be a sandy lime, sometimes resembling chalk. West of Leopol, the soil is a light yellowish sandy earth, resembling that of the richest part of the calcaire grossier of the Netherlands. East of Leopol is a deep black soil exactly resembling that of the most fertile parts of Russia; both appear to cover the same formation, and they are equally productive.

Dec. 6.—A paper was read, "On the Geology of some Parts of Arabia, and some Islands in the Persian Gulph," by J. B. Fraser, Esq.

This paper contains geological observations on a part of the

coast of Arabia, and several islands in the Persian Gulph, and was accompanied by specimens collected in the countries which he describes. On a voyage from Bombay to Bushire (near the head of the Persian Gulph), Mr. Fraser had an opportunity of examining the country round Muscat, and for a distance of some miles in the interior; where there is a considerable extent of serpentine and of stratified calcareous rocks. He landed also on the island of Rishm, consisting of a formation probably very recent; while the rocks on Ormus seem almost wholly primitive.

Two letters were read from W. Hamilton, Esq. his Britannic Majesty's Minister Plenipotentiary at the Court of Naples, to Dr. Granville, MGS. giving a description of the late eruption of Vesuvius.

Dec. 20.—Part of a letter to Dr. Wollaston, VPGS. from Dr. Fitton, was read, containing an account of the geology of the vicinity of Boulogne, and notifying the author's intention to present a memoir on this subject to the Society. This notice was accompanied by a map and sections of the district included by the chalk, from the place where it leaves the sea near Wissant, to where it rejoins it to the west of Neufchatel and Samer.

A paper from George Cumberland, Esq. was read, describing the strata round Dursley, Stroud, and other places on the Banks of the Severn, and in the county of Gloucester, with a description of some fossils found in several beds of the oolite formation.

Jan. 3.—A letter was read from the late Rev. John Wright, rector of one of the principal parishes in Nassau, on the Bahamas, transmitted to Professor Buckland, in compliance with a late circular letter from Earl Bathurst to the colonies, giving an account of the geological structure of the Bahamas.

These islands, which stretch in length not less than 600 miles, appear to be a very recent formation. They are all calcareous, and have a strong resemblance to each other in their general features. A very full and interesting account of their physical structure, products, and geographical relations, is furnished by Mr. Wright's paper, with a description of some curious caverns and valuable salt lakes in which many of them abound.

Article XI.

Scientific Intelligence, and Notices of Subjects connected with Science.

I. *Electro-Magnetic Experiment.* By Prof. Oersted.

Although there are many proofs that every point in the circumference of a round galvanic conductor has an equal action on the magnetic needle, yet it appears that several authors are of the contrary

opinion. The reason of this may be, that no method has hitherto been devised of giving the needle any desired situation with respect to the conductor; and although Paggendorf has thrown much light on this subject, by employing magnets for the purpose of giving the needle any situation at pleasure, yet the respective intensity of action which each point exerted on the needle remained undecided in his experiment.

Prof. Oersted has endeavoured, by the following experiment, to remove all doubts on this subject. A brass wire, 10 feet long, and 1-36th of an inch in diameter, is placed in a perpendicular position on the side of a column, at the middle of which is a stand to place the needle on. Both ends of the wire are placed in small vessels filled with mercury; by these it communicates with a single pair of plates on the Professor's construction, in which the vessel is of copper; and in order to prevent the influence of the other parts of the apparatus, this is so constructed that they remain far distant from the needle during the experiment. The galvanic apparatus is fixed on the middle of a pole 10 feet long; one of the conductors passes over the upper end of the pole, and the other beneath the lower one; and from thence they are brought, in a horizontal direction, each into contact with the mercury in one of the small vessels. The entire apparatus is of a rectangular figure.

The pole with the galvanic apparatus is now made to revolve in a circle around the perpendicular wire and the needle: during the experiment, therefore, every point in the wire will constantly change its position with respect to the galvanic apparatus, and will be, in succession, on the inner and on the outer side of the galvanic chain. In a series of experiments in which the apparatus went round at least three-fourths of the circumference, the needle constantly exhibited the same declination which it had at the moment when the galvanic circuit was completed. It appears, therefore, from these experiments, that no doubts can be entertained, but that every point in the circumference of the conductor has the same effect upon the magnetic needle.

II. *Existence of Metallic Veins in the Transition Limestone of Plymouth.*

It has hitherto been believed, that the extensive strata of limestone in the neighbourhood of Plymouth, which belong to the Transition class of Werner, or to the Submedial order of the Rev. W. D. Conybeare's new arrangement of rocks, are altogether devoid of metallic veins. The Rev. Richard Hennah, in his "Succinct Account of the Lime Rocks of Plymouth," lately published, being the Substance of his communications respecting them to the Geological Society, says, p. 18, "The bed of Plymouth limestone appears to be entirely free from all *metallic veins;* and I have not seen, nor have I heard, of any thing tending to what miners would call a *lode,* of any of the metals, having ever been discovered in any one of the quarries that have hitherto been opened. It is true that indications of the presence of *iron,* and also of *manganese,* may occasionally be seen, as a colouring matter, in particular spots; but always thinly spread, and never in any quantity."

Mr. Hennah also states, that, in a single instance, he has observed "spots of pyrites in fragments of limestone and slate," found in sinking

a well at Stonehouse; and that he has been told, that in digging another well, on the road leading from Plymouth to Cat-Down; "particles of pyrites were observed by the workmen employed, and also a *glimpse of copper;*" but he expresses strong doubts of the accuracy of this relation.

It appears, from the following circumstance, that this subject demands a more rigorous investigation: in a collection of specimens from the Plymouth limestone, recently brought to London, is an assemblage of small quartz crystals, mingled with *crystalline galena;* upon the galena are small lenticular crystals of *carbonate of iron,* and the amorphous mass of quartz into which the crystals pass, is mixed with a greenish-grey substance not unlike chert, in which are disseminated minute cubes of *iron pyrites.* The entire specimen bears every character of having once formed part of the lining of a cavity in a vein: it was procured from a quarry at Cat-Down.

Article XII.

NEW SCIENTIFIC BOOKS

PREPARING FOR PUBLICATION.

Observations on the Functions of the Digestive Organs, especially those of the Stomach and Liver; with practical Remarks on the Treatment of some of the Diseases to which these Organs are liable. By W. Prout, MD. FRS. &c. &c.

*** This Work will comprise the results of an experimental inquiry into the nature of some of the more important chemical changes which take place during the digestion and assimilation of the food. The practical remarks will principally relate to the proper adjustment and use of remedies, and to the pernicious effects liable to be produced in delicate habits by the constant operations of various slowly acting causes, especially impure or *hard* waters: illustrated by analyses of the principal waters in common use in the metropolis and its vicinity.

An Account of an Expedition from Pittsburgh to the Rocky Mountains, performed in the Years 1819, 1820, by Order of the Hon. J. H. Calhoun, Secretary of War, under the Command of Major S. H. Long, of the United States, Topographical Engineer. By Edwin James, Botanist and Geologist to the Expedition. In Three Volumes, with Maps and Charts.

An Account of a Voyage to Greenland in the Summer of 1822, with an accurate Map of that remote Region, by Mr. Scoresby.

JUST PUBLISHED.

A Universal Technological Dictionary, or familiar Explanation of the Terms used in all Arts and Sciences; containing Definitions drawn from original Writers, and illustrated by 60 Plates, and very numerous Wood-Cuts of Diagrams, Arms, &c. By George Crabb, AM. Author of "English Synonymes Explained." In Two Volumes, 4to. Price 5*l.* 8*s.*

Transactions of the Royal Geological Society of Cornwall, instituted Feb. 11, 1814. Vol. II. with Six Maps, &c. 8vo. 16s.

Dr. Faithhorn on Diseases of the Liver and Biliary System, comprehending those various, extensive, and often complicated Disorders of the Digestive, Internal Organs, and Nervous System, originating from these Sources. The Fifth Edition. With an Appendix of Cases, illustrative of the Principles of Treatment. 8vo. 9s. Boards.

A new Map of the Ear, exhibiting its external, intermediate, and internal Structure, together with the principal Nerves and Blood Vessels in its immediate Vicinity, designed as an Anatomical Illustration of that important Organ. By J. H. Curtis, Esq. Aurist to the King. 6s. coloured.

Researches respecting the Medical Powers of Chlorine, particularly in Diseases of the Liver; with an Account of the new Mode of applying the Agent, by which its Influence on the System can be secured. By W. Wallace, MRIA. Member of the Royal College of Surgeons in Ireland, Lecturer on Anatomy and Surgery, &c. 8vo.

A new View of the Infection of Scarlet Fever, illustrated by Remarks on other contagious Disorders. By W. Macmichael, MD. FRS. &c. Physician Extraordinary to the Duke of York, &c. 8vo.

Article XIII.

NEW PATENTS.

J. Brindley, Finsbury, near Rochester, ship-builder, for improvements in the buildings of ships, &c.—Oct. 18.

T. Leach, of Blue Boar-coat, Friday-street, Cheapside, for an improvement in steam-engines. Communicated to him by a foreigner. —Oct. 25.

W. Piper, of Cookley Iron-works, Wolverley, Worcestershire, civil engineer, for several new anchors, for the use of shipping and other vessels.—Nov. 1.

A. Flint, of Uley, Gloucestershire, engineer, for a machine for scouring, pising, and washing of woollen cloth.—Nov. 1.

J. Oxford, of Little Britain, for an improved method of preventing premature decay in timber, metallic substances, and canvass.—Nov. 1.

J. D. Moxon, Liverpool, ship-owner, for improvements in the construction of bridges, and works of a similar nature.—Nov. 9.

F. Deakin, Birmingham, sword manufacturer, for an improvement in the manufacture of holster-cases, cartouch-boxes, and certain other description of cases.—Nov. 9.

J. Jekyll, of Roundhill House, Wincanton, Somersetshire, for improvements in steam or vapour baths.—Nov. 9.

R. Roberts, of Manchester, civil engineer, for improvements in the process of weaving plain or figured cloths, or fabrics.—Nov. 14.

J. Egg, Piccadilly, gun-maker, for certain improvements in the construction of guns and fire-arms, upon the self-priming and detonating principle.—Nov. 26.

Article XIV.

METEOROLOGICAL TABLE.

1822.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.	Daniell's hyg. at noon.
12th Mon.								
Dec. 1	S W	29·50	29·21	49	35	—	26	
2	S W	29·40	29·20	42	33	—	42	
3	N	29·70	29·40	43	30	—		
4	S W	29·92	29·70	49	31	—	35	
5	S W	29·70	29·59	46	35	—	33	
6	N W	30·08	29·70	45	31	—		
7	N W	30·35	30·08	40	28	—		
8	S W	30·35	30·25	48	32	—		
9	S W	30·47	30·23	48	32	—	—	
10	N W	30·65	30·47	44	26	—		
11	N E	30·66	30·63	33	24	—		
12	N E	30·63	30·50	40	29	—		
13	E	30·50	30·42	39	30	—		
14	S E	30·42	30·25	36	26	—		
15	N E	30·29	30·25	37	31	—		
16	N E	30·47	30·28	36	30	—		
17	N W	30·47	30·35	42	31	—	—	
18	N E	30·36	30·34	45	35	—		
19	N E	30·47	30·36	38	27	—		
20	N E	30·47	30·46	36	26	—		
21	N E	30·46	30·30	35	26	—		
22	N E	30·30	30·23	38	32	—		
23	N E	30·23	30·21	42	34	—		
24	N E	30·55	30·21	35	31	—		
25	E	30·57	30·55	34	23	—		
26	S E	30·55	30·49	36	18	—		
27	E	30·49	30·41	34	14	—		
28	N E	30·41	30·30	29	19	—		
29	N E	30·30	30·03	31	20	—		
30	E	30·03	29·93	30	23	—		
31	E	29·94	29·93	31	27	·98		
		30·66	29·20	49	14	·98	1·36	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Twelfth Month.—1. Rainy. 2. Fine day: rainy night. 3. Fine. 4. Rainy. 5. Fine day; between eight and nine, p.m. rain commenced with a very brisk wind from the SW, which increased during the night to a violent gale. 6. Very windy morning: cloudy. 7. Foggy. 8. Fine. 9. Cloudy. 10. Very fine morning: fine day. 11. Hoar frost: very foggy day: cleared off at night. 12. Hoar frost: fine day. 13. Fine. 14. Foggy. 15. Cloudy. 16. Raw cold: overcast. 17. Foggy. 18. Cloudy: atmosphere heavy. 19. A strong bleak wind. 20. Bleak. 21. Fine and clear. 22. Fine. 23, 24. Cloudy. 25. Cloudy and fine. 26. Fine: bright moonlight night. 27. Fine: clear. 28. Hoar frost. 29, 30. Fine. 31. A little snow in the afternoon.

RESULTS.

Winds: N, 1; NE, 13; E, 5; SE, 2; SW, 6; NW, 4.

Barometer: Mean height

For the month.................................... 30·208 inches.

For the lunar period, ending the 5th .... 29·743

For 12 days, ending the 5th (moon north)........... 29·590

For 15 days, ending the 20th (moon south).......... 30·373

Thermometer: Mean height

For the month.................................... 33·548°

For the lunar period.............................. 37·724

For 29 days, the sun in Sagittarius.................. 38·172

Evaporation.. 0·98 in.

Rain... 1·36

Laboratory, Stratford, First Month, 22, 1823. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

MARCH, 1823.

Article I.

Memoir on the probable Situation and Prospects of the Expedition under Capt. Parry. By Henry Edmonston, Esq.*

(To the Editor of the *Annals of Philosophy*.)

SIR, *Jan.* 7, 1823.

The last ships of the season have long since arrived from Davis's Straits, the year has closed, and time slips on; yet we hear no tidings of our countrymen, who, twenty months ago, sailed on the expedition for the discovery of a North West Passage. The public mind, seldom long alive to any thing, but lately awakened for a moment to this subject by the return of Capt. Franklin, seems again to have sunk into its usual state of repose. Did our adventurers but know how small a share of the general sympathy and attention their situation engrosses at any given period, it would not much tend to cheer the dulness of their long and dreary polar winter. But though in some measure forgotten by their country, they live in the hopes and fears of kindred and friends left behind, and in the anxieties of those who know how to estimate the magnitude and danger of the enterprise, and to do justice to their heroism and intrepidity. The indifference on the part of the public at large is peculiarly ill-judged, for at no stage in the history of this extraordinary project, since it was first set on foot by Cabot, did it ever possess such an intensity of interest as it does at the present

* Read before the Literary and Philosophical Society of Newcastle-upon-Tyne.

moment. To every mind of reflection and sensibility, I do not doubt but that this sentiment will be sufficiently familiar. But for the purpose of rousing, and, if possible, of keeping alive, attention to the subject, it will be the business of the following remarks to place some of the circumstances connected with it in as prominent a point of view as the shortness of the time within which I have to prepare this article will allow. I obtrude no speculations on the importance of a north-west passage. This, together with the history of the various attempts made to effect it, are well known to all who are the least conversant with the study of maritime geography. I may, however, hazard one observation, that, setting aside every other consideration, it does appear to be, under suitable circumstances, an object worthy of the first maritime nation in the world, to take the lead in determining all questions of this kind, even though no other result should follow, than the ascertaining of a geographical fact. Such exploits are in strict accordance with many of our most interesting national associations and habits. Besides, to Great Britain belongs the glory of having first instituted voyages of discovery for the mere purposes of extending the boundaries of natural knowledge, and of benefiting mankind. Moreover, it belongs to the reign of George III. and will transmit that reign to posterity, with a lustre that will throw into shade many of the political events, singular as they have been, which have occurred during the sixty years that it lasted. Much, it is true, had been done previous to the accession of our late monarch towards perfecting the knowledge of the globe, but it had been done with selfish and sordid views, for the sake of national or individual emolument. It was reserved for this country, in our own times, to set an example of beneficence such as the world had never witnessed, viz. the exploring of new and distant regions in order that civilization and happiness might be more widely diffused.* The north-west expedition then, had it no other claim to our regard, would be entitled to it on the ground of its having been sent out in furtherance of those laudable and enlightened designs. But it also has its own peculiar claims; such, indeed, as are calculated to call forth our utmost solicitude and admiration.

We know that a certain number of our countrymen have now been absent for a long period on a most perilous service; that they have already encountered one hyperborean winter, and must now be amidst the hardships and privations of another; in regions, perhaps, never before visited, certainly never before resided in by Europeans, and under circumstances, though not altogether new, in the highest degree trying and difficult. We

* It is a fact not undeserving of notice, that the first expedition sent out with the views here stated, sailed shortly after the accession of his late Majesty; while the last, and, perhaps, the only important achievement of the kind remaining to be accomplished, left the country in the year in which he died.

know them to be bold and resolute; zealous and persevering in the discharge of their duty, dreading nothing so much as failure. On the other hand, there is the experience of a former voyage; the prospects thence opened out, a certain share of national reputation hanging on the event, the honour that must accrue from success; nay, that must attach even to failure. In short, a thousand considerations all of them most deeply interesting, and tending powerfully to fix on this expedition the notice of the world, and assuredly to engage our warmest sympathies on behalf of those who have embarked in it. A few conjectures then, respecting the probable situation and condition at present of this brave band, and also as to their prospects for the future, will not, we hope, be considered mistimed at this season; to us one of rejoicing and festivity, to them, probably, one of dreariness and darkness.

Next to the honour of participating in their hazardous pursuit, is the pleasure we derive from following them in our mind's eye, or from tracing their fancied route on the map; joining in their labours, and entering into their difficulties. While thus employed, we feel, as if by taking a part, we lightened their toils; and we at all events discharge the duty we owe them of taking a lively concern in their affairs, the belief of which on their part, we may be assured, helps, perhaps, more than any thing else, to cheer the dull monotony of their abode, and constitutes one of the principal means of enabling them to bear up under the pressure of hardships or misfortunes. Let us then endeavour to follow them, and, if possible, to find them out.

Various situations present themselves in which we may imagine them to be placed, some of them more or less difficult; some of them dangerous. Before pointing these out, however, we shall attempt to assign the limits so far as respects latitude and longitude, within which their course must have lain, and within which they must in all probability be, if alive, and their object still unattained. In doing this, although there be few data of any kind, and still fewer upon which we can approximate with any thing like precision to the spot that they are likely to be now occupying, we can at least say with some certainty where *they are not;* and even this negative knowledge, in the absence of something better, is not wholly unimportant.

It is not easy to guess accurately *where* the entrance from the North Atlantic has been made. The experience, however, of the former voyage—the fact of their not having been traced or heard of by any of the whalers—the views of Capt. Parry himself—and other considerations—lead to the belief that the place of entrance has been sought for, and found, either through Hudson's, Frobisher's, or Cumberland Straits, and thence northward by either Sir Thomas Rowe's Welcome, Repulse Bay, or Fox's Farthest. It will save some trouble if we at once take this for granted.

Cape Chidley in 60° north latitude, at the south entrance of Hudson's Straits, and Possession Bay at the south entrance of Lancaster Sound, will consequently be their utmost distance in latitude; while their space in longitude will not here considerably exceed 20°, which, at this distance from the equator, is not much. It is not till they reach the latitude of 66° or 67° that their longitude becomes considerable, extending to Icy Cape, or probably to Cape Prince of Wales; that is, as far as the 168th degree of west longitude, and comprising not less than from 80° to 90°; while the latitude suffers a corresponding diminution, not including, at the furthest, more than 6° or 7°. This is owing to the particular direction of the land and water. Within the boundaries denoted by these rough numbers, our navigators, in all probability, must be. But we may, if we choose, very much circumscribe these limits; and, for the sake of aiding our speculations, it may be well to do so. We shall, therefore, confine them between the parallels of 66° and 72°, and between 80° and 168° west longitude. In this estimate it is assumed, that Capt. Franklin has given to the Copper Mine River a lower latitude than Hearne did; and we may venture to do this with safety, both from what has transpired respecting his voyage, and from a conjecture hazarded with great foresight by Capt. Parry in his Journal. It will also stretch as far north as Prince Regent's Inlet, explored in the last expedition.

On casting the eye over the map, there is one thing that cannot fail to strike the most superficial observer, viz. the near correspondence in latitude (or at least within a very few degrees of each other) of four cardinal points, now ascertained to exist; namely, Fox's Farthest, the mouth of the Copper Mine River, the mouth of Mackenzie's River, and Icy Cape. From well authenticated facts, as well as from many circumstances of a conjectural character, such as the probable direction of currents, tides, &c. it amounts to almost a certainty, that between the latitudes of 67° or even lower, and 75°, and for the whole longitude already mentioned, there is an extensive surface of water more or less open. Whether continuously so from the North Atlantic to the North Pacific, or whether permanently obstructed by land or ice, remains to be seen. So far as Capt. Parry's former survey goes, there has not yet been discovered any æstuary communicating with it between Cumberland Strait and Lancaster Sound, though it might be expected that a body of water of such magnitude would make itself known by an outlet not liable to doubt or mistake. We are not, however, to lay too much stress upon this; the Sound and the Straits of Gibraltar being familiar examples to the contrary. Still, no passage having been found, full liberty is allowed to presume that Hudson's Bay through Sir Thomas Rowe's Welcome and the neighbouring passages, forms the prolongation eastward of this vast expanse, and that Hudson's Straits generally, as comprehending Frobisher's and

Cumberland Straits, is the main channel by which it communicates with the Northern Atlantic. Through these Straits then we assume that Capt. Parry, agreeably to his own expectations and speculations, made good his entrance in the summer of 1821. The question comes, where is he now? and what is to become of him? It would indeed be most gratifying, could a reply of definite probability be given to this question; were it but to soothe the mind for a time into tranquillity, and to dissipate a portion of that uneasiness which must otherwise be felt. But this is not to be done, and we must be content with such conjectures as circumstances seem to warrant.

It is quite needless to imagine that they could have got through into Behring's Straits the first season. Such a supposition, though favourable to their object, is fatal to their existence; because they must have been either at home, or heard of, long ago. There can be no hesitation then in rejecting this notion.

The *first* supposition we shall hazard, then, is, that during the summer of 1821 they found admission somewhere in the vicinity of the channel already specified, and that favoured by their former experience, the accidental openness of the season, the lower degree of latitude, and other concurrences, and keeping the American coast fast on board, they penetrated to a considerable distance, say beyond the longitude of the Copper Mine River, and that on the return of summer 1822, they recommenced operations, went forward, passing Mackenzie's River, and pushed through into Behring's Straits, either by some outlet north of Cape Prince of Wales, such as Kotzebue's Sound, or by doubling Icy Cape, probably last September. This is clearly the most favourable supposition that can be made. Should it prove correct, we may begin to expect intelligence very soon, or in the course of the ensuing spring, either by the Isthmus of Darien and the West Indies, or we may see them by the East Indies, or Cape Horn, according to the route by which they return, which will doubtless be left to Capt. Parry's discretion.* We cannot anticipate early news by Kamtschatka and Petersburg, the journey being so long and tedious.

The supposition now made, however, though a possible case, is a barely possible one. The presumptions are all adverse to it. We have placed our adventurers at the end of the first season beyond the mouth of the Copper Mine River, for the sake of making every allowance, rather than because it is probable they could have reached thus far. The probability is, they did not, and this is corroborated by another probability, that they may have been detained a long time, perhaps nearly a season, in doing little more than finding a channel by which they might advance, as happened to a certain extent in the former voyage,

* From this view it is obvious, that the circumstance of our not yet having heard of them ought not, by itself, to occasion the least disquietude.

while exploring Prince Regent's Inlet. In the second place, it assumes the passage to be almost straight, and free, which assumption has little to countenance it. Thirdly, the new and more circuitous route; and although this may be compensated in some degree by a longer season in a lower latitude, and fewer obstructions than in Lancaster Sound, yet the compensation appears scarcely adequate to the purpose. We cannot make out from any satisfactory data the length of the working season under the parallels in question. In lat. 51°, at the south corner of Hudson's Bay, Capt. James found his movements impeded by ice so early as October, and was obliged to lay up for the winter by the end of November; it was June before he could stir, and August before the ship was disentangled, making little more than four clear months, and even during the whole summer, the bay was infested with ice. The entire working period in Lancaster Sound, at least in the meridian of Melville Island, which is exactly that of the Copper Mine River, did not exceed 49 days, according to Capt. Parry. Now the parallels under which we have placed the expedition are upwards of 15° north of Charlton Island, where James wintered, and certainly not more than 7° south of Lancaster Sound. If then we give three complete months for the open working season, it may be all that can well be allowed. If Capt. Franklin was able to survey 500 miles of coast, it would argue to be sure a pretty long season for active operations, though, on the other hand, the winter appears to have set in upon him so early as the end of August. But here we are all in the dark, not long to continue so we trust. Fourthly, if they kept hold of the American coast, which Capt. Parry deems essential to success, they might have been seen or heard of by Capt. Franklin, had they penetrated to within even 200 miles of the longitude of the Copper Mine River. Yet this of itself is not much; the natives may have destroyed their signals and beacons; besides, they might easily pass unseen by Capt. Franklin. Fifthly, admitting that they did get beyond the Copper Mine River the first season, still there is an unexplored way of equal or greater length lying between them and the longitude of Behring's Straits, which would occupy fully as much, if not more time in exploring. At least so we must conceive of it, especially if we keep in mind that the forward advance of one season is no absolute criterion by which we can judge of the advance made in another. Capt. Parry, not having, during the whole summer of 1820, pushed westward 10 miles beyond the spot to which he reached in 1819. Sixthly, there is a fact stated by this able commander, that the quantity of ice kept increasing as they advanced *westward;* and although he accounts for this with his usual penetration, by the increasing distance from the coast of the ocean, and expects it not to happen after reaching midway, but, on the contrary, that it would decrease as they approached the western sea coast of America, from the well-

known greater mildness of the temperature on the American than on the Asiatic coast; yet it is difficult to pronounce how far this calculation would be found to agree with actual experience. At all events, the accumulation of ice is likely to be sufficient, even in the lower latitude, to cause much obstruction; and to retard the progress so far, as to induce the necessity of wintering for the second time in these arctic latitudes. And this brings us to the second supposition, which we beg to hazard; namely, that they have proceeded beyond the Copper Mine, or even beyond Mackenzie's River during this last summer (1822), and have pushed forward; but though the passage may eventually prove to be pervious, that they have been obstructed by climate, season, and other impediments, before they could launch upon the Pacific by Behring's Straits; and that they are actually now passing the winter at some point short of that desirable goal. In this case no reasonable fears can be entertained for their safety. The wintering on Melville Island has set this question at rest. If all have gone well with them, not a doubt can arise as to their capability of sustaining another winter in a lower latitude, fortified by two years' experience, and doubtless amply provided. Though the risk to health will of course be somewhat greater (as appears by the reiterated apprehensions of Capt. Parry), yet we may confidently hope, that with the earliest return of summer, they will press forward, and penetrate into Behring's Straits, probably by next August or September (1823). In this case, it will be the end of 1823, or the beginning of 1824, before they, or any intelligence of them, can arrive in this country. This supposition embraces all the probabilities of the former one, with others, and the important adjunct of time superadded. It is the one to which we most incline, because it seems to meet many of the objections likely to be urged, and it is effectual for the accomplishment of a north-west passage, if such do exist in the direction they may have taken; while it is consistent with their perfect safety, which more than all is important; even granting that a little beyond the spot where they are now sojourning, they should find themselves impenetrably opposed by ice or land, or to have sought for the passage in a wrong direction, an occurrence, by the way, not unlikely to happen, they may still get back in the course of the ensuing summer; and by October or November, we may hail their arrival.

The next, or third supposition, is not so favourable, involving, as it does, the likelihood of some danger, and the certainty of some difficulty, if not hardship. It is this; suppose, as we have already done, that they last summer reached, and are now wintering somewhere beyond Mackenzie's River, but considerably short of Behring's Straits; and suppose that after having resumed their efforts next summer, and proceeded to some distance, they should not be so fortunate as to find a channel lower

than Icy Cape, and their attempts to pass that promontory be rendered fruitless by ice; in the same manner as at the end of Melville Island, though there appeared to be no want of sea;* and that they should in consequence be obliged to return the way they went: then comes a question, can they retraverse in half a season; nay, perhaps, in little more than the mere remnant of a season, the space advanced in nearly three seasons?

This question we should hope may be settled in the affirmative, though there be some points connected with it which do not leave us entirely free from doubt. In Lancaster Sound, they sailed back in six days the distance advanced in six weeks, owing to the setting of the current from west to east; so that if upon a more southerly parallel the current set in the same direction, and with the same rapidity, we are unwilling to indulge any misgivings as to their ability to effect the run back, and we shall have the satisfaction of welcoming them next autumn; and though ever so unsuccessful, welcome them we shall; for highly as we may be disposed to account the discovery of a north-west passage, we set an incomparably higher price on the lives of those who have gone in search of it.

But let us imagine unexpected impediments to present themselves; severity of the weather, change in the direction, or increase in the quantity of the ice, a difference in the set or swiftness of the current compared with that in Lancaster Sound, various localities, and other matters of which we can form no adequate idea, rendering it impossible for them to reach the Atlantic in the course of next season: then comes a serious question, Can they subsist for another or a third winter in the polar regions? Are they supplied with provisions, fuel, and clothing, for this purpose? In the former voyage, they were equipped for two years, which, by the bye, was too short, and had nearly proved so, and shows the calculation to have been defective. For how long they have been this time equipped and victualled, we have not learned,† and, therefore, can found upon it no calculation. But if the supposition now thrown out should ultimately prove the correct one, it must be three years and a half from the time of their leaving this country before they can revisit the British shores, or obtain a fresh supply; that is, it will be, not next November, but November, 1824, before they come back. This is a long time for fuel and provisions to last. Under the impression that he might be compelled to winter a second time in Lancaster Sound, Capt. Parry put his people to a reduced allowance of every thing; that is, to two-thirds of the usual navy allowance, a measure which led him to entertain some uncomfortable anticipations, regarding its effect on health as well as the effects of so long a deprivation of fresh animal and

* Cook and Clerk found themselves opposed about Icy Cape by ice in July and August.

† It has been said three years.

more especially of fresh vegetable aliment. The bad consequences of a third winter, therefore, might be fearfully augmented, were there not reason to expect that the supply of game will be more abundant further south than it was in Melville Island. Cartwright, in Labrador, shot plenty of deer and bears, even in the depth of winter, long and severe though it was. There will be besides, somewhat less gloom and darkness, and altogether a shorter winter. There will, probably, too, be more of esculent vegetables, and we have the satisfaction of knowing, that Donkin's preserved animal food, of which their stock must be abundant, undergoes no deterioration by any length of keeping to which it has yet been subjected. The article of fuel gives us more concern. One thing, however, is certain; that from the skill, prudence, and resource, of the commander; and from the zeal and devotedness of his followers, every thing may be expected. Thus we may still cherish well grounded hopes that they will be able, inured to the climate as they must then be, in some measure, to withstand even a third polar winter, should it be necessary. And this will tend to relieve us from much anxiety as to the preservation of their lives.

The views already taken have gone upon the principle that all is to continue prosperous (God grant it may !), so far as respects their health, subsistence, and means of protection, against the rigour of the climate; and without taking into the account any untoward accident. But let such occur, a deficiency in their resources from damage to the ships, injury to the provisions and stores, sickness disabling them from exertion; what sort of predicament would they then be in! What complicated miseries may they be made to endure! It is possible, then, and, perhaps, not so improbable as could be wished, that, according to the fourth and last, and worst supposition of all, they may have been overtaken by some calamity; their ships wrecked, or cut up by the ice; their stock of every thing wholly or partially destroyed; themselves thrust out with such means as the moment supplied, to find their way over frozen wastes, in a climate destructive to every thing that lives, save foxes, and wolves, and bears! From such a view, however distant, the imagination involuntarily recoils, and would gladly take shelter, if it could, in the brighter prospects already held out. But difficulties and dangers to be overcome must be looked, as our gallant heroes will look at them, full in the face. Some faint conception may be formed of such a situation from what appears to have befallen Capt. Franklin; with this difference, that *their* hardships would be enhanced tenfold, inasmuch as they would be ignorant of the country, and unable to avail themselves of its resources. It is then not impossible but that, in the course of the voyage, they may be plunged into this miserable state, perhaps at no great distance from Hudson's Bay; perhaps at some

station far remote, casting many a longing look in vain for help, and wasting under the accumulated horrors of cold, disease, and starvation! This may be thought an overcharged picture! Perhaps it is so. May it not turn out the true one!

Upon such a view of their situation, what does it become the duty of the country to do?

Whatever speculative enthusiasts may say in their closets of the national honour, maritime glory, eclat, and so forth, to be derived from the discovery of a north-west passage, the exposing of men's lives to the greatest hazards for the attainment of such an object is at all times a matter of serious import. We know, indeed, that Capt. Parry and his companions went on this adventure upon their own sole responsibility, and with the full knowledge of its perils, "for all are volunteers from the highest to the lowest," says a journal of some authority, when speaking of the former voyage. Yet this requires qualification; many circumstances may conspire to render a service strictly and severely compulsory, without the aid of the impress; and at all events the fact takes nothing from the heavy responsibility resting on all who have charge and superintendence in this business. And this brings us at last to the main object of the present memoir.

To use the words of a celebrated commander, "England expects" Capt. Parry and his associates "to do their duty." —*They will do it;*—but they have a right to expect the country to do its duty by them.

When men are sent on an imminently dangerous enterprise, the least that the country can do is to evince a constant sensibility to their condition, and to be forward in using every practicable means for their preservation, never losing sight of the maxim, that it is both wiser and more humane in such cases, to do too much than too little.

We may be all but certain, that they are wintering for the second time in a high northern latitude, an act in itself not exempt from risk, even under the most favourable circumstances; but under any disaster, dangerous in the extreme. What would have been the fate of Capt. Franklin and his party, had they not arrived when they did at the friendly post of the Hudson's Bay Company?

Let it not be understood for a moment that I am here putting forward these surmises as disheartening forebodements, calculated to wound the sensibilities of relatives and friends. Such a design would be as base as the attempt would be futile. Besides, my hopes have always been strong, and will continue stedfast. But on behalf of our voyagers, I do frankly confess to a degree of anxiety, bordering on impatience and restlessness. Besides, I wish the whole matter should be seen, that the country may be made thoroughly sensible of the greatness of the services which

these brave men are rendering in order that her honour may be promoted. Moreover, though it ought not to be doubted that every thing relating to this expedition has been considered with the calmest and most mature deliberation, yet we have seen expeditions sent out, the calculations of which had for their basis, not the probabilities of failure, but the bare possibilities of success. Now success carries with it, or creates, its own resources, and may well be left to itself. I may remark too that, every other circumstance apart, the situation of Capt. Parry is one unprecedented in the history of this country. It may well, therefore, justify a degree of provident care that might otherwise be accounted excessive. On the former expedition difficulties were met with that had not been anticipated, and in all undertakings of this sort, events occur which no judgment can forecast. It is to prevent or to remedy misfortune, then, that precautions are to be taken; and the plan to be adopted almost suggests itself.

Let dispatches be forthwith sent to the Governors of Canada and Hudson's Bay, and to the North-West Company, directing them to equip different parties of natives to go in search by the Copper Mine River, Mackenzie's River, and such other routes as may be thought expedient. Let them take out plentiful supplies of all kinds. Let the richest rewards be secured to them in case of success, and to their families (by way of encouragement) in case of disaster befalling them. The tribes who accompanied Hearne think little of travelling to the mouth of the Copper Mine River, and the esquimaux evidently migrate even beyond Lancaster Sound. Let each expedition (and we would forward twenty, if requisite) be accompanied, if thought proper, by one or two adventurous individuals from this country as a check to ensure their fidelity. The danger to them under the guidance of natives would be nothing. Such expeditions might be effected with ease and certainty in the course of one short spring or summer. Capt. Parry himself when discussing the subject of a north-west passage, expressly anticipates "the chance of being enabled to send information by means of the natives, and the comparative facility with which the lives of the people might be saved in case of serious and irreparable accidents to the ships." (Journal, p. 298.)

The object being simply to *search* and obtain news, not to *survey* (and this is of some consequence), a great extent of ground may be gone over, and first rate scientific men are not required. Not an instrument need to be taken out, excepting, perhaps, a quadrant, or pocket compass, to determine latitudes and courses. Repeated expeditions have of late years proceeded to the mouth of Mackenzie's River and the Copper Mine River in pursuit of less worthy objects.

Where too would be the harm of ordering out, this very spring,

two or three small ships of war on different routes; one to make for Sir Thomas Rowe's Welcome, or Repulse Bay; another for Fox's Farthest; and a third to look into every creek and corner on the coast of Baffin's Bay, as far even as Lancaster Sound or further; though there be no great likelihood of the entrance being made this time so much to the northward.

Why also might not the Davis's Straits' Whalers be encouraged by a bounty to sail a few weeks earlier than usual, and to employ the time in exploring the coast all the way to the fishing ground? In a word, suppose any thing and every thing to be done most likely to promote the great objects in view; namely, the preservation of our dear countrymen and the character of our country.

Should the apprehensions set forth in this memoir be treated as chimerical, I can only express my hearty prayers that the event may prove them to have been so; or should it be objected that the proposed measures would be premature, the time not having yet arrived when they may be called for, I reply, *that it is not the time to send help when it is needed.* Months must elapse before it can by possibility reach them, and months or weeks, nay days, are too precious when the time of their trouble comes. Every one will allow, at least, that the aid had better come too soon than too late; and that hundreds of thousands of pounds had better be expended in superfluous precautions than that a single man should perish by neglect or delay.

I trust that the department of the public service to which the management of all this affair has been exclusively confided, is fully and feelingly alive to the duty which it has to discharge on this occasion. Nay it is by no means improbable, that the measures now suggested have long been in contemplation. Most unfeignedly shall I rejoice should this prove true. But public boards cannot find leisure to attend to every thing; and I am so unreasonable as to think, that on such an occasion, we ought, if possible, to be prepared for all chances. We cannot forget that La Perouse might have been saved or heard of had ships been timely sent out in search, instead of waiting years beyond the extreme period allowed for the fulfilment of his instructions. But France was then in her political agony. For her, therefore, there was the appearance of excuse or palliation. For us there can be none. But even as it is, the name of Perouse can never be uttered or thought of without feelings of the deepest sympathy, regret, and indignation. Besides, nothing satisfactory could be anticipated from the labours of those sent out under Entrecasteaux; for they were evidently more engrossed by their party squabbles, than with the noble object of their search; and, in fact, when the commander died, they actually quarrelled on these paltry grounds, and separated. Again, the very character and mode of conducting the expedition were

sufficient to ensure disappointment. Their purpose was, or ought to have been, *search*, and *nothing else;* to touch or look in every where; to rest no where a moment longer than was indispensable. Instead of this, they were provided with naturalists, astronomers, geographers, engineers, and all the paraphernalia and *instructions* suited to a voyage of *discovery;* and consequently spent much of their valuable time in details foreign to that sacred duty which should have occupied their sole and undivided attention. And to crown the whole, the two ships were dispatched *together;* instead of taking separate routes, by which the chances of gaining their object would have been at least doubled. However, not to dwell any longer on the mistakes of our neighbours, let us endeavour to profit by them, and above all, let not the bitter reproach lie against this country of having "left undone that which she ought to have done."

Article II.

Astronomical Observations, 1822, 1823. By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Jan. 22. Emersion of Jupiter's second satellite	6h	46′	39·0″	Mean Time at Bushey.
	6	48	00·0	Mean Time at Greenwich.
Jan. 24. Immersion of ι Gemini by the moon	5	58	05·5	Mean Time at Bushey.
Feb. 13. Emersion of λ Pisces by the moon	6	16	55·0	Mean Time at Bushey.

Memorandum.—The greatest degree of cold last month at this place was 16° below freezing, and this occurred on the morning of the 20th.

On the 19th, when the thermometer here stood at 17½°, it sunk at Bushey Grove, the seat of David Haliburton, Esq. to zero. Bushey Grove is about 200 feet lower than Bushey Heath.

Article III.

Meteorological Register kept at Helston for 1822. By M. P. Moyle, Esq.

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Jan. 1	29·755	47·00	—	—	0·14	NW	Boisterous	Heavy rain	—
2	29·810	42·93	—	—	0·08	NW	Boisterous	Hail showers	—
3	29·550	45·00	—	—	0·33	SW	—	Rain	—
4	29·860	41·60	—	.	—	NE	—	Cloudy; fine	—
5	29·940	39·60	—		—	NE	—	Fine, showers	—
6	30·040	35·00	—	—	0·07	NE	—	Frost, cloudy	—
7	29·950	40·60	—	—	0·05	NE	—	Hail; fine	—
8	30·130	40·30	—	—		NE	—	Cloudy	—
9	30·186	41·60	—	—	0·07	NE	—	Cloudy	—
10	30·186	46·66	—	—	—	NW	—	Cloudy; fog	—
11	30·286	49·33		—		NW	—	Cloudy	—
12	30·396	51·00	—	—	0·06	NW	—	Cloudy; rain	—
13	30·350	49·33	—	—	0·04	W	—	Cloudy; hazy	—
14	30·410	49·53	—	—	0·02	NW	—	Slight clouds	—
15	30·336	49·00	—	—	—	NW	—	Cloudy	—
16	30·183	48·00	—	—	0·09	NW	—	Showery	—
17	30·246	47·30	—	—	0·06	N	—	Cloudy	—
18	30·400	44·30	—	—	—	NW	—	Cloudy; rain	—
19	30·376	48·30	—	—	0·02	W	—	Cloudy	—
20	30·273	50·60	—	—	0·02	NW	—	Cloudy; hazy	—
21	30·350	47·00	—	—	0·01	NW	—	Cloudy; fine	—
22	30·350	48·60	—	—	—	W	—	Cloudy	—
23	30·116	51·00	—	—	—	S	—	Cloudy; rain	—
24	29·986	50·66	—	—	0·21	WNW	—	Rain	—
25	30·216	48·30	—	—	—	N	—	Cloudy	—
26	30·276	49·30	—	—	—	NW	—	Fine	—
27	30·276	50·30	—	—	0·12	NW	—	Rain	—
28	30·253	49·00	—	—	—	NW	—	Cloudy	—
29	30·250	48·50	—	—	—	N	—	Cloudy; rain	—
30	30·313	48·00	—	—	0·08	NE	—	Fine	—
31	30·263	46·00	—	—	—	SW	—	Cloudy	—

1822.	Barom.	Com. Ther.	Register. Max	Register. Min	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Feb. 1	30·060	48·66	—	—	—	SW	—	Fine	—
2	29·626	52·00	—	—	0·01	SW	—	Rain	—
3	29·500	46·00	—	—	0·47	W	—	Showery	—
4	29·413	47·30	—	—	—	SE	—	Rain	—
5	29·516	49·00	—	—	0·36	W	—	Cloudy; rain	—
6	29·926	47·30	—	—	—	S	—	Frost; fine	—
7	29·606	50·06	—	—	—	SW	—	Rain	—
8	29·763	49·00	—	—	0·37	SW	—	Fine	—
9	29·570	52·10	—	—	—	S	—	Rain	—
10	29·706	46·60	—	—	0·37	W	—	Rain	—
11	29·950	41·00	—	—	0·09	N	—	Fine	—
12	30·076	41·00	—	—	—	SE	—	Very fine	—
13	29·953	45·60	—	—	—	S	—	Fine	—
14	29·880	53·00	—	—	—	SE	—	Very fine	—
15	30·043	51·30	—	—	—	SE	—	Fine	—
16	30·330	50·00	—	—	—	S	—	Fine	—
17	30·355	54·00	—	—	—	W	—	Cloudy	—
18	30·315	53·60	—	—	—	SW	—	Cloudy	—
19	30·346	47·30	—	—	—	NW	—	Very fine	—
20	30·150	48·00	—	—	0·46	NW	—	Heavy showers	—
21	30·376	44·00	—	—	—	N	—	Very fine	—
22	30·210	50·30	—	—	—	SW	—	Cloudy	—
23	30·293	46·30	—	—	—	SW	—	Fine	—
24	30·243	51·30	—	—	—	W	—	Cloudy	—
25	30·220	50·30	—	—	—	SW	—	Cloudy	—
26	30·193	50·00	—	—	0·04	SW	—	Showers	—
27	30·530	48·00	—	—	0·02	N	—	Very fine	—
28	30·390	42·30	—	—	—	SSE	—	Fine	—
Mean	30·018	48·46			2·19				

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Mar. 1	30·176	50·60	—	—	—	SSW	—	Fine	—
2	30·173	58·00	—	—	—	S	—	Cloudy; rain	—
3	30·153	50·66	—	—	0·05	SSW	—	Cloudy; fine	—
4	29·883	50·30	—	—	0 47	SW	—	Rain	—
5	29·910	58·00	—	—	0·07	SW	—	Rain	—
6	29·670	54 24	—	—	0·44	SW	—	Rain	—
7	29·690	46·60	—	—	—	W by S	—	Showery	—
8	29·683	46 90	—	—	0·16	W by S	—	Cloudy; showers	—
9	29 840	53·30	—	—	0·11	SW	—	Cloudy	—
10	29 716	55 30	—	—	0 4	SW	—	Cloudy	—
11	30·016	49 00	—	—	—	W	—	Cloudy	—
12	30·180	48 30	—	—	—	W	—	Fine	—
13	29 873	53·60	—	—	—	SE	—	Fine	—
14	29 993	48 60	—	—	—	W	—	Very fine	—
15	30·113	52·60	—	—	—	S	—	Cloudy	—
16	30 070	53·60	—	—	0·15	SSW	—	Rain	—
17	30·183	53 60	—	—	—	SW	—	Misty rain	—
18	30·330	52 60	—	—	0·04	NW	—	Very fine	—
19	30 340	54 60	—	—	0·03	W by N	—	Rain; cloudy	—
20	30·293	54 00	—	—	—	NW	—	Fine	—
21	30 243	52 40	—	—	—	NW	—	Very fine	—
22	30·400	50·20	—	—	—	SW	—	Very fine	—
23	29 986	51 03	—	—	—	S	—	Very fine	—
24	29 733	48 00	—	—	0·05	W	—	Showers	—
25	29·853	46 00	—	—	0·20	W	—	Rain	—
26	30 140	53·57	—	—	—	SW	—	Foggy; fine	—
27	30 030	59 50	—	—	—	SE	—	Fine	—
28	30·103	53 00	—	—	0·01	SW	—	Misty rain	—
29	30 306	53·00	—	—	—	S	—	Cloudy; rain	—
30	29 936	51·00	—	—	0·08	NW	Stormy	Cloudy	—
31	30·426	44·30	—	—	—	N	—	Very fine	—
Mean	30·046	51·55			1·88				

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
April 1	30·400	45 6	—	—	0·03	N	—	Showers; fine	—
2	30 350	48·3	—	—	—	NE	—	Fine	—
3	30·356	47·6	—	—	—	NE	—	Fine	—
4	30·273	47·6	—	—	—	NW	—	Fine	—
5	30·023	51·3	—	—	—	N	—	Fine	—
6	29 986	49·0	—	—	—	NW	—	Very fine	—
7	30·023	47·3	—	—	—	NNW	—	Cloudy	—
8	30·016	44·6	—	—	0·16	NE	Boisterous	Cloudy; rain	—
9	30·050	42 6	—	—	0·03	NE	—	Hail showers	—
10	29·953	42·6	—	—	0·03	N	Stormy	Hail showers	—
11	29·746	47·0	—	—	0·10	NE	—	Fine	—
12	29·396	51·3	—	—	0 55	SE	—	Heavy rain	—
13	29·760	52 0	—	—	0·25	S	—	Showery	—
14	29 936	51·6	—	—	—	SW	—	Very fine	—
15	29·910	55 3	—	—	—	NE	—	Fine	—
16	29·966	53·0	—	—	—	N	—	Very fine	—
17	29·853	53·3	—	—	—	NW	—	Cloudy; fine	—
18	29 710	50·2	—	—	0·05	NW	—	Fine; showery	—
19	29 706	50·0	—	—	0·02	NW	—	Fine	—
20	29·580	52 0	—	—	—	SW	—	Rain	—
21	29·246	53·0	—	—	0 14	S	—	Rain	—
22	29·110	48 0	—	—	0·45	SW	—	Heavy showers	—
23	29 196	51·0	—	—	0·28	SW	—	Fine	—
24	29·370	52 6	—	—	0·10	SSW	—	Rain	—
25	29 596	51 6	—	—	0·40	SW	—	Cloudy; showers	—
26	29.900	54·3	—	—	0·05	SW	—	Cloudy	—
27	29·960	52·0	—	—	0·43	NW	—	Rain; cloudy	—
28	30·140	57 3	—	—	—	SW	—	Cloudy	—
29	30·100	61·6	—	—	—	E	—	Very fine	—
30	30·106	63·0	—	—	—	E	—	Very fine	—
Mean	29·858	51·88			3·07				

1882.	Barom.	Com. Ther.	Register. Max.	Register. Min	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
May 1	30·146	58·3	—	—	—	E by N	Brisk	Very fine	—
2	30·050	57·6	—	—	—	E	Brisk	Very fine	—
3	29·726	60·3	—	—	—	E	Mild	Cloudy	—
4	29·509	62·6	—	—		E	Moderate	Showers	—
5	29·566	63·6	—	—	0·05	SE	Mild	Fine	—
6	29·620	66·0	—	—	0·02	SE	Mild	Fine	—
7	29·726	64·0	—	—	—	EWS	Variable	Thunder ; cloudy	—
8	29·830	66·3	—	—	—	NE	Fresh	Very fine	—
9	29·580	57·3	—	—	—	S	Brisk	Gloomy ; rain	—
10	29·353	51·3	—	—	0·12	N	Brisk	Cloudy ; rain	—
11	29·410	56·3	—	—	0·18	SE	Brisk	Cloudy ; rain	—
12	29·806	54·6	—	—	0·17	N	Fresh	Cloudy ; showers	—
13	29·850	57·0	63	47·0	—	N	Fresh	Fine	—
14	29·860	58·3	67	48·0	—	NW	Gentle	Very fine	—
15	29·896	55·6	60	49·0	—	NW	Brisk	Fine ; fog	—
16	29·916	59·0	64	43·0	—	N	Mild	Fine	—
17	29·943	58·3	65	49·0	—	N	Fresh	Very fine	—
18	30·040	53·6	60	48·0	—	NW	Brisk	Very fine	—
19	30·040	55·3	64	48·0	—	NW	Moderate	Very fine	—
20	30·116	57·3	64	47·0	—	NW	Brisk	Very fine	—
21	30·226	57·3	65	51·0	—	NW	Very fresh	Very fine	81·0
22	30·216	61·0	69	47·0	—	E	Gentle	Very fine	82·0
23	30·043	58·3	63	57·0	—	E by S	Brisk	Fine	70·0
24	29·906	56·0	64	50·0	—	E by N	Very brisk	Very fine	80·0
25	29·833	60·0	67	48·0	—	E by N	Fresh	Very fine	81·0
26	29·836	54·0	59	53·0	0·14	SW	Fresh	Fine ; rain	74·0
27	30·026	59·0	64	46·0	—	SW	Gentle	Fine ; rain	73·0
28	30·180	56·0	65	52·0	0·14	NW	Gentle	Cloudy	76·0
29	30·226	59·3	65	48·0	—	SW	Gentle	Very fine	76·0
30	30·230	60·3	67	52·0	—	SW	Gentle	Very fine	76·0
31	30·250	60·6	66	51·0	—	W	Gentle	Very fine	76·0
Mean	29·578	58·2	65	49·3	0·82				76·8

1882.	Barom.	Com. Ther.	Register. Max.	Register. Min	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
June 1	30·193	62·0	67·0	58·0	—	NW	Fresh	Cloudy	76·0
2	30·160	61·0	67·0	58·0	—	NNW	Gentle	Fine ; fog	78·0
3	30·096	67·0	76·0	54·0	—	E	Gentle	Very fine	91·0
4	30·060	69·3	77·0	61·0	—	E	Fresh	Very fine	91·0
5	30·090	71·6	84·0	63·0	—	SE	Very mild	Very fine	99·0
6	30·083	73·3	81·0	61·0	—	E	Brisk	Very fine	96·0
7	30·016	64·6	76·0	61·0	—	E	Very fresh	Very fine	86·0
8	29·830	66·3	71·0	59·0	0·15	E	Very fresh	Thunder ; rain	86·0
9	29·810	66·6	78·0	58·0	0·11	SE	Fresh	Cloudy ; fine	86·0
10	29·876	63·0	70·0	58·0	0·31	SE	Gentle	Rain ; cloudy	81·0
11	30·043	64·6	73·0	54·0	—	E	Mild	Very fine	93·0
12	30·073	64·6	74·0	59·0	069	NE	Moderate	Rain ; thunder	78·0
13	30·014	61·0	69·0	53·0	—	E	Moderate	Fine	86·0
14	29·760	65·6	75·0	53·0	0·03	E	Fresh	Rain ; thunder	91·0
15	29·653	65·3	71·0	60·0	0·03	SW	Brisk	Cloudy	85·0
16	29·806	65·3	74·0	56·0	0·10	SE	Very brisk	Rain ; fine	87·0
17	30·093	63·0	72·0	58·0	—	E	Boisterous	Cloudy	84·0
18	30·090	63·6	72·0	54·0	—	NE	Brisk	Very fine	88·0
19	29·906	59·0	71·0	55·0	—	N	Brisk	Fine	83·0
20	29·930	60·6	69·0	54·0	—	NW	Fresh	Cloudy	80·0
21	30·033	62·0	68·0	54·0	—	NE	Very brisk	Very fine	86·0
22	29·963	65·6	76·0	56·0	0·22	E	Moderate	Thunder ; hail	89·0
23	29·966	64·6	68·0	56·0	0·01	SW	Very brisk	Cloudy	82·0
24	30·083	65·3	73·0	55·0	—	SW	Gentle	Cloudy	88·0
25	30·073	66·0	73·0	54·0	—	SW	Moderate	Cloudy ; fine	88·0
26	30·020	65·3	68·0	58·0	0·06	NW	Brisk	Showery	80·0
27	30·176	62·0	71·0	56·0	—	NW	Fresh	Cloudy ; fine	78·0
28	30·036	62·0	67·0	60·0	0·13	SW	Stormy	Rain	77·0
29	30·156	58·0	63·0	52·0	—	NW	Very fresh	Cloudy	70·0
30	30·050	58·6	64·0	55·0	0·11	NW	Very brisk	Rain ; cloudy	72·0
Mean	30·029	64·35	71·8	56·6	1·93				88·8

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
July 1	30·103	60·3	66	55	—	NW	Brisk	Cloudy	74·0
2	29·920	60·6	68	49	0·03	SW	Gentle	Cloudy; rain	78·0
3	29·960	61·0	68	58	0·03	SW	Gentle	Cloudy; showers	82·0
4	29·890	60·6	73	59	—	S	Gentle	Showery	80·0
5	29·773	61·6	68	56	0·36	NW	Gentle	Rain	70·0
6	29·943	59·6	66	52	—	NW	Brisk	Cloudy	77·0
7	30·136	62·6	67	60	—	NW	Brisk	Fine	81·0
8	30·263	60·6	66	54	—	NW	Brisk	Cloudy	70·0
9	29·993	64·6	75	58	0·04	SW	Gentle	Showers	82·0
10	29·896	63·0	69	56	0·27	SW	Gentle	Cloudy; showers	82·0
11	29·610	60·6	67	50	—	S	Brisk	Cloudy	70·0
12	29·680	56·6	62	50	0·67	NW	Boisterous	Rain	67·0
13	29·933	63·3	68	60	—	SW	Brisk	Cloudy	79·0
14	29·903	67·6	74	59	0·17	SW	Gentle	Rain; thunder	88·0
15	29·756	60·6	62	57	1·02	E	Brisk	Rain	63·0
16	29·780	59·6	66	50	0·39	NW	Brisk	Cloudy	82·0
17	29·640	62·0	69	59	—	SW	Gentle	Fine	86·0
18	29·513	64·0	69	57	0·25	SE	Brisk	Cloudy; rain	76·0
19	29·270	64·0	70	57	—	SE	Brisk	Cloudy	82·0
20	29·363	63·0	67	56	0·41	SW	Fresh	Cloudy	69·0
21	29·570	63·6	67	58	—	W	Very fresh	Showers	75·0
22	29·726	62·0	67	59	0·08	SW	Fresh	Cloudy	73·0
23	29·550	64·0	68	59	0·19	SW	Gentle	Rain; cloudy	78·0
24	29·536	60·3	63	58	0·45	SW	Brisk	Heavy rain	76·0
25	29·676	61·6	67	53	0·24	SW	Fresh	Fine	79·0
26	29·730	61·6	69	50	—	SW	Gentle	Cloudy	76·0
27	29·570	60·3	65	55	0·60	SE	Gentle	Heavy rain	69·0
28	29·446	60·6	65	51	1·03	SW	Fresh	Heavy rain	70·0
29	29·540	60·3	65	52	0·36	SW	Gentle	Fine; showers	70·0
30	29·650	57·0	61	50	—	NW	Gentle	Very fine	73·0
31	29·736	56·0	66	51	0·15	NW	Fresh	Rain; fine	67·0

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Aug. 1	29·796	57·0	66·0	50·0	0·07	NW	Gentle	Showery	84·0
2	29·886	57·0	63·0	46·0	0·08	NW	Very fresh	Fine	75·0
3	29·963	60·3	66·0	54·0	—	S	Gentle	Cloudy	77·0
4	29·780	59·6	65·0	51·0	0·26	E	Gentle	Rain	72·0
5	29·940	57·3	62·0	50·0	—	N	Gentle	Cloudy	65·0
6	30·040	57·6	63·0	46·0	—	N	Gentle	Cloudy	67·0
7	30·053	60·3	68·0	53·0	—	S	Gentle	Cloudy; fine	77·0
8	29·990	63·3	69·0	57·0	—	S	Gentle	Cloudy; fine	88·0
9	29·813	62·0	68·0	55·0	0·05	SW	Variable	Fine	83·0
10	29·800	61·3	67·0	55·0	0·02	SW	Gentle	Cloudy	82·0
11	29·780	61·0	64·0	54·0	—	SW	Light	Cloudy	72·0
12	29·850	63·0	67·0	58·0	0·17	SW	Moderate	Heavy rain	80·0
13	29·883	63·3	69·0	62·0	0·06	W	Brisk	Cloudy	84·0
14	29·730	64·3	69·0	53·0	0·06	S	Very brisk	Rain; cloudy	83·0
15	29·903	60·6	65·0	56·0	—	W	Very brisk	Fine	82·0
16	30·113	63·3	63·0	56·0	0·04	SW	Gentle	Slight rain	77·0
17	30·216	64·0	73·0	54·0	0·02	SW	Gentle	Fine	99·0
18	30·126	64·6	73·0	56·0	—	E	Gentle	Cloudy	82·0
19	30·043	67·6	75·0	56·0	—	E	Fresh	Very fine	99·0
20	30·000	67·3	75·0	56·0	—	E	Very fresh	Fine	94·0
21	29·956	68·6	77·0	61·0	—	NE	Gentle	Very fine	101·0
22	29·943	68·3	69·0	52·0	—	NW	Gentle	Cloudy; fine	85·0
23	30·008	59·0	65·0	51·0	—	NW	Fresh	Fine	87·0
24	29·716	59·0	64·0	52·0	0·22	S	Very fresh	Rain; cloudy	88·0
25	29·733	57·6	63·0	53·0	0·05	SW	Very fresh	Cloudy; showers	76·0
26	29·720	59·0	65·0	54·0	0·11	NW	Very fresh	Showery	76·0
27	29·636	61·3	65·0	53·0	—	SW	Fresh	Cloudy	79·0
28	29·506	60·3	67·0	53·0	—	S	Gentle	Cloudy	73·0
29	29·633	56·0	67·0	46·0	0·30	W	Very fresh	Rain	75·0
30	29·763	54·6	66·0	44·0	0·14	SW	Gentle	Rain; fine	83·0
31	29·960	55·3	63·0	44·0	—	NW	Gentle	Very fine	82·0

1822.	Barom.	Com. Ther	Register. Max	Register. Min	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Sept. 1	30·100	56·6	64·0	55·0	—	SW	Gentle	Very fine	86·0
2	30·046	62 6	72·0	52·0	—	SW	Gentle	Cloudy ; fine	78·0
3	30·026	60 6	66 0	53·0	—	W	Gentle	Fine	76·0
4	30·040	63·2	67 0	60·0	—	SW	Gentle	Cloudy	70·0
5	29·820	61 6	66·0	58·0	—	SW	Brisk	Cloudy ; misty	68·0
6	29 880	59·3	65·0	49·0	—	W	Fresh	Fine	80·0
7	30·070	58·6	65·0	57·0	—	SW	Fresh	Fine	86 0
8	29·980	59 3	67·0	53·0	—	SW	Gentle	Small rain	73·0
9	30 000	55·6	61·9	47 0	0·13	NW	Brisk	Showers	63·0
10	30·066	60·6	67 0	47·0	0·05	S	Gentle	Cloudy ; rain	82·0
11	29 856	59·3	65 0	52·0	—	S	Gentle	Cloudy	86 0
12	29·886	56 6	60·0	52·0	0·05	NE	Fresh	Cloudy ; rain	74·0
13	29·910	59·0	65·0	57·0	-	E	Fresh	Cloudy	67·0
14	29 970	58·6	63 0	56 0	—	E	Very brisk	Fine ; cloudy	86·0
15	29·863	57 3	67·0	50·0	—	E	Gentle	Fine	81·0
16	29 989	64·0	71·0	59·0	—	E	Gentle	Cloudy	80·0
17	29·916	67·0	71·0	59·0	0·02	SE	Gentle	Misty ; fine	93·0
18	29 960	62·3	70·0	53·0	—	NE	Very fresh	Very fine	81·0
19	29·893	59·0	65·0	52·0	—	E	Boisterous	Very fine	76·0
20	29 750	59·0	62·0	51 0	—	E	Boisterous	Cloudy	73·0
21	29·733	57 6	63·0	50·0	—	E	Brisk	Cloudy	73·0
22	29·780	57 6	64·0	47·0	0·16	NE	Brisk	Cloudy	63·0
23	29·633	56·3	61·0	53·0	—	E	Gentle	Cloudy ; rain	65·0
24	29·213	56·6	63·0	52·0	0·30	NW	Gentle	Rain	86·0
25	29·493	53·0	58·0	46·0	0·39	NW	Brisk	Fine ; rain	76·0
26	29·695	48·3	54 0	41·0	0·28	NE	Fresh	Showery	57·0
27	30·173	49·3	56·0	46·0	0·03	NE	Fresh	Very fine	76·0
28	30·130	51·6	60·0	42·0	—	NNE	Fresh	Very fine	81·0
29	29·976	55·5	60·0	45·0	—	E	Gentle	Very fine	84·0
30	29·720	54 0	60·0	48·0	—	E	Gentle	Very fine	71·0
Mean	29·838	58·09	63·9	47·5	1·41				76·5

1822.	Barom.	Com. Ther.	Register. Max	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Oct. 1	29·5060	57·0	59·0	51·0	0·65	E	Fresh	Rain	63·0
2	29·5760	58·6	62·0	56·0	0·06	E	Gentle	Cloudy	70·0
3	29·5093	59·0	65·0	53·0	—	E	Gentle	Fine ; fog	81·0
4	29·4623	60·3	64·0	50 0	—	E	Gentle	Cloudy	70·0
5	29·4703	55 3	59·0	48·0	0·34	SW	Moderate	Rain	63·0
6	29·6261	53·6	56·0	52·0	—	NW	Very fresh	Showery	63·0
7	29·4830	56·0	59·0	53·0	0·45	SW	Stormy	Rain ; cloudy	83·0
8	29·4053	55·0	59·0	51·0	0·07	SW	Stormy	Showery	71·0
9	29·5600	53·3	56·0	49 0	0·19	SW	Very brisk	Showery	72·0
10	29·8890	52·3	60·0	48·0	0·14	SW	Very fresh	Hail showers	70·0
11	30·0333	55·0	62·0	53·0	—	SW	Gentle	Showery	74·0
12	29 5000	57·6	62·0	54·0	0·10	SE	Gentle	Rain	73·0
13	29·7060	54·3	57 0	47·0	0·20	NW	Very brisk	Small rain	56·0
14	30·0580	50·3	53·0	44 0	—	NE	Stormy	Fine	82·0
15	29·7420	51·3	60·0	43·0	—	SE	Gentle	Fine ; showers	72·0
16	29 4646	50·6	62·0	43·0	0·35	N	Gentle	Rain ; fine	83·0
17	29·6533	48 6	55·0	33·0	—	N	Brisk	Cloudy	65·0
18	29·5920	49·0	56·0	33·0	—	SW	Gentle	Rain ; cloudy	58·0
19	29 5400	55 0	57·0	55·0	0·26	SW	Stormy	Showery	57·0
20	29·4213	55·3	58 0	50·0	0·28	S	Brisk	Rain ; cloudy	61·0
21	29·5926	51·0	59·0	39 0	0·09	SW	Fresh	Showery	72·0
22	29·7433	50 3	53·0	51·0	0 08	S	Gentle	Fine	83·0
23	29·3046	55·0	64·0	52·0	—	S	Fresh	Gloomy	66·0
24	29 1940	55 0	60·0	50·0	0·56	SE	Gentle	Rain	71·0
25	29·4820	54·3	58·0	51·0	—	S	Moderate	Fine	83·0
26	29·5373	51 0	57 0	44·0	0·56	W	Gentle	Rain ; cloudy	57·0
27	29·5780	50·3	54·0	50·0	0·35	W	Brisk	Rain ; cloudy	54·0
28	29·8126	54·6	59·0	50 0	0·03	S	Gentle	Showers	71·0
29	29·9600	55·0	60 0	52·0	0·14	NW	Gentle	Showers	75·0
30	29·7090	54·3	61·0	53·0	0·05	SE	Brisk	Showers	62·0
31	29·7160	56·3	62·0	52·0	—	S	Gentle	Fine; cloudy	75·0
Mean	29·9397	53·95	57·74	50·17	4·66				68·32

1822.	Barom.	Com. Ther.	Register. Max	Register. Min	Rain	Wind.	Strength.	Weather.	Therm. in sun.
Nov. 1	29·7160	50·6	62·0	55·0	0·53	S	Boisterous	Rain	58·0
2	29·7686	55·3	63·0	49·0	0·11	SW	Boisterous	Rain; cloudy	70·0
3	30·1820	50·6	55·0	42·0	0·13	W	Fresh	Showers	71·0
4	30·3536	50·3	55·0	50·0	—	W	Brisk	Fine	74·0
5	30·4253	51·3	58·0	52·0	0·01	SW	Fresh	Cloudy	65·0
6	30·1793	50·3	56·0	51·0	—	S	Gentle	Cloudy	66·0
7	29·9306	54·0	57·0	50·0	—	SW	Gentle	Cloudy	64·0
8	29·9980	51·0	53·0	48·0	—	NE	Gentle	Cloudy	62·0
9	29·7913	53·6	58·0	47·0	0·14	SE	Gentle	Rain	56·0
10	30·1433	58·6	53·0	46·0	0·55	NW	Very fresh	Rain; fine	57·0
11	30·1900	53·3	57·0	54·0	—	S	Very brisk	Cloudy	56·0
12	30·0130	52·6	59·0	39·0	—	S	Brisk	Rain	53·0
13	29·9826	52·0	53·0	43·0	0·52	SW	Brisk	Rain	67·0
14	29·5283	49·3	54·0	43·0	0·23	SW	Stormy	Heavy showers	59·0
15	29·3920	45·6	49·0	40·0	0·30	SW	Boisterous	Thun., showers	49·0
16	29·4493	45·6	48·0	39·0	0·05	N	Fresh	Showers	61·0
17	29·6160	50·6	53·0	48·0	0·05	SW	Very brisk	Showers	54·0
18	29·7326	51·0	54·0	50·0	0·20	W	Moderate	Small rain	54·0
19	29·7630	53·3	55·0	50·0	0·01	SW	Stormy	Cloudy	59·0
20	29·6280	50·6	53·0	44·0	0·68	SW	Gentle	Heavy rain	55·0
21	29·8506	47·3	50·0	46·0	0·09	SW	Brisk	Showery	64·0
22	29·7166	52·6	53·0	46·0	0·31	SW	Boisterous	Rain	52·0
23	29·7346	49·3	51·0	47·0	0·31	SW	Boisterous	Rain	59·0
24	29·6506	52·3	55·0	48·0	—	SW	Very brisk	Showery	57·0
25	29·4400	50·3	55·0	47·0	0·21	SW	Stormy	Heavy showers	58·0
26	29·5440	50·0	54·0	46·0	0·89	SW	Very fresh	Heavy showers	55·0
27	29·6993	47·0	50·0	41·0	0·10	W	Stormy	Small rain	59·0
28	29·5106	47·0	52·0	41·0	0·26	W	V. boister	Heavy showers	55·0
29	29·4616	43·3	47·0	56·0	0·63	SW	Boisterous	Heavy showers	54·0
30	29·6106	44·6	48·0	41·0	0·31	W	Stormy	Heavy showers	58·0
Mean	29·7900	50·33	53·9	45·9	6·62				59·3

1822.	Barom.	Com. Ther.	Register. Max.	Register. Min.	Rain.	Wind.	Strength.	Weather.	Therm. in sun.
Dec. 1	29·2476	49·6	51·0	35·0	0·14	SW	Stormy	Showers	52·0
2	29·1020	39·6	44·0	30·0	0·08	SW	Gentle	Showers	51·0
3	29·5080	41·3	46·0	40·0	—	NW	Moderate	Fine	62·0
4	29·6660	47·3	50·0	37·0	—	W	Brisk	Cloudy	51·0
5	29·7246	44·0	50·0	44·0	0·34	W	Very brisk	Rain	51·0
6	29·9186	44·3	48·0	34·0	0·29	NW	Brisk	Showers	54·0
7	30·1520	43·0	46·0	33·0	0·05	NW	Brisk	Showers	57·0
8	30·2073	47·3	49·0	44·0	0·04	SW	Fresh	Gloomy	50·0
9	30·1600	47·0	50·0	35·0	—	SW	Gentle	Misty	50·0
10	30·4740	38·6	45·0	33·0	0·20	N	Gentle	Fine	57·0
11	30·4793	45·0	47·0	40·0	—	S	Gentle	Small rain	47·0
12	30·4380	42·3	45·0	34·0	0·02	E	Brisk	Fine	56·0
13	30·3353	37·6	46·0	30·0	—	E	Gentle	Fine	57·0
14	30·1960	34·6	44·0	37·0		NE	Gentle	Fine	44·0
15	30·0326	39·6	41·0	30·0	—	E	Brisk	Sleet; cloudy	54·0
16	30·2300	32·6	38·0	26·0	—	NE	Very brisk	Fine	52·0
17	30·2218	35·6	47·0	36·0	—	NE	Moderate	Rain	43·0
18	30·2933	45·6	48·0	38·0	0·13	NE	Moderate	Cloudy	49·0
19	30·2746	39·6	42·0	30·0	—	NE	Moderate	Fine	51·0
20	30·3040	31·3	35·0	27·0	—	NE	Brisk	Fine	42·0
21	30·2413	31·3	35·0	28·0	—	NE	Brisk	Fine	48·0
22	30·0666	34·6	39·0	32·0	—	NE	Brisk	Very fine	48·0
23	30·0360	38·0	40·0	30·0	—	NE	Moderate	Cloudy	42·0
24	30·0936	38·3	42·0	33·0	—	NE	Moderate	Cloudy	43·0
25	30·3700	36·0	38·0	35·0	—	NE	Moderate	Cloudy	41·0
26	30·2920	38·6	42·0	35·0	—	E	Brisk	Cloudy	50·0
27	30·2533	37·3	39·0	35·0	—	SE	Gentle	Cloudy	46·0
28	30·0610	40·3	45·0	35·0	—	SE	Gentle	Cloudy	46·0
29	29·7943	44·3	46·0	35·0	0·16	SE	Brisk	Rain	48·0
30	29·6586	35·6	39·0	31·0	0·24	E	Very brisk	Cloudy	43·0
31	29·7353	34·3	41·0	30·0	—	NW	Gentle	Fine	46·0
Mean	30·0558	39·91	43·7	33·9	1·69				49·3

1822.	Barometer.				Common thermometer monthly mean.	Register Thermometer.			Reg. Therm. in Sun.			Wind.									Weather.		
	Maximum observed.	Minimum observed.	Mean of the month.	Monthly range.		Maximum observed.	Minimum observed.	Monthly mean.	Maximum observed.	Minimum observed.	Monthly mean.	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Prevailing winds.	Wet days.	Dry days.	Rain in inches.
January ...	30·4200	29·1500	30·3140	01·2700	46·54	—	—	—	—	—	—	3	8	0	0	1	2	3	14	NW	11	20	1·45
February...	30·5800	29·1800	30·0180	01·4000	48·46	—	—	—	—	—	—	3	0	0	5	4	9	5	2	SW	9	19	2·19
March.	30·4500	29 6200	30·0460	00·8300	51·55	—	—	—	—	—	—	1	0	0	2	6	9	8	5	SW	13	18	1·88
April	30·4300	29·1000	29·8580	01·3300	51·88	—	—	—	—	—	—	6	3	2	1	4	4	1	9	NW	16	14	3·07
May	30·2600	29·2300	29·5780	01·0300	58·20	69·0	43·0	57·1	82	43·0	76·8	7	1	8	3	0	5	3	5	N	7	24	0·88
June	30·2000	29·6500	30·0290	00·5500	64·35	84·0	52·0	64·2	99	52·0	70·2	1	1	12	4	1	4	0	7	E	12	18	1·93
July	30·2200	29·1600	29·7410	01·0600	61·40	75·0	49·0	60·5	88	49·0	64·8	0	0	1	3	2	14	2	9	SW	19	12	6·74
August....	30·2300	29·4500	29·8930	00·7800	60·90	77·0	44·0	59·4	101	44·0	76·0	2	1	5	0	4	9	4	6	SW	15	16	1·65
September. .	30·2000	29·1800	29·8580	01·0200	58·09	72·0	41·0	55·7	93	41·0	62·0	1	5	11	1	2	6	1	3	E	9	21	1·41
October....	30·0720	29·1460	29·9397	00·9260	53·95	65·0	39·0	52·34	83	39·0	59·54	2	1	4	4	6	9	2	3	SW	21	10	4·86
November. .	30·3800	29·3060	29·7900	01·0740	50·33	63·0	36·0	49·94	74	36·0	59·30	1	1	0	1	4	17	5	1	SW	25	5	6·62
December. .	30·5000	29·0780	30·0558	01·4220	39·91	51·0	26·0	38·50	69	26·0	44·0	1	11	5	2	1	4	2	5	NE	10	21	1·60
Annual Means, &c.	30·32416	29·2708	29·9258	01·0576	53·796							28	31	48	26	35	92	36	69	SW	167	198	34·31

Barometer.

Highest, Feb. 27.	Wind, N	30·5800
Lowest, Dec. 2.	Wind, SW	29·0780

Register Thermometer.

Highest, June 5.	Wind, SE	84°
Lowest, Dec. 16.	Wind, NE.	26

Register Thermometer in the Sun.

Highest, Aug. 21.	Wind, ENE.	101
Lowest, Dec. 16.	Wind, NE.	26

Common Thermometer.

Highest, June 5.	Wind, SE	83
Lowest, Dec. 20.	Wind, NE.	28

Wet days comprehend rainy, showery, snowy, and those in which there was a fall of hail.

My pluviameter is situated on the top of a chimney, 30 feet above the ground, and free from the operation of any local circumstances.

January.—The winter has been remarkably mild; no snow, and only a few showers of hail and sleet, which were dissolved as fast as they fell. The last 24 days of this month, the barometer stood uniformly (one day excepted) above 30 inches. If the addition for the elevation of the barometer was made, the last 27 days of the month, the mercury stood above 30 inches.

February and *March.*—These months also were remarkably mild. Only one day on which we had any frost.

April.—This month was rather stormy, with many hail showers.

May.—This month was remarkably fine; many days excessively hot for this season of the year.

June.—A very fine month. Heat very oppressive, particularly on the 5th.

July.—More rain in this month than has ever before been recorded, being 19 days rain.

August and *September.*—Generally speaking fine months.

October.—Very stormy on the 7th and 8th; wind from the SW.

November.—Several days in this month particularly rough; blowing very strong on the 23d, 24th, 25th, and 28th. The latter day was attended with very sudden squalls, raging to a perfect hurricane, and in a minute subsiding, to be renewed with equal violence. On the evening of this day, there was a very beautiful lunar rainbow.

December.—Generally speaking very mild. A few days sharp frost, with gentle wind: 23 days of this month, making the proper addition, the barometer stood more than 30 inches high.

N. B. As my house, or rather the site of my barometer, is situated 105·9 feet above the sea level, it must be necessary to add 0·104 inch to all the barometrical heights in the foregoing tables for the correct heights of mercury. The tables contain the means of three daily observations; viz. 8 p.m.; 1 a.m.; and 10 a.m. The most prevailing wind of the 24 hours is only given; and the register thermometer placed in the sun is insulated six feet from any thing capable of reflecting heat, and the scale of it is marked on the glass tube itself.

Helston, Jan. 4, 1823. M. P. Moyle.

Article IV.

Essays on the Construction of Sea Harbours. By Mr. J. B. Longmire.

(To the Editor of the *Annals of Philosophy.*)

Sir, *Whitehaven, Jan.* 9, 1823.

This subject being new to the public, you may deem the following essays worthy of insertion in the *Annals*, more especially as you occasionally have papers in it on civil engineering.

The matter under consideration naturally falls under two parts; namely, entrances into sea harbours; and the situations and relative positions of the piers of such harbours.

I. *Of Entrances.*

All entrances into sea harbours may be classed under two heads: in the first, they face the sea, and admit the surf;* and in the second, they face the calmest quarter, while the surf passes to the lee shore without entering the harbour.

In constructing a harbour to make a proper entrance is a very important task; as a harbour that is safe within loses much of its value, if not accessible in every wind that a ship can approach it from the main ocean.

Before describing the theory of entrances, it is necessary to show how vessels approach a harbour in different winds. A ship can sail best with the wind, and her course to any object to the leeward is in a straight line; and although she cannot sail directly against the wind, she can either reach or pass any object to the windward, by making alternate approaches, which have angles of 6½ points, or 73° 7′ 30″, with the wind: this is called tacking. When a vessel is sailing with the wind from the

* The surf is a term applied to express the state of the sea's surface near the shore in a high wind, or in a gale; and signifies the rapid succession of great waves that pass to and strike the shore.

north point, having her bowsprit N, 73° 7′ 30″ W, she is on the starboard tack; and on the larboard tack, if in the same wind, her bowsprit point N, 73° 7′ 30″ E. Thus if a vessel sail along the line *c e*, fig. 1, to *a*, the wind blowing in the direction *g a*, she is on the starboard tack, the line *d e* making an angle of 73° 7′ 30″ with the line *g a*; and for the same reasons, in the same wind, she is on the larboard tack, when sailing along the line *b a*. Hence by sailing with the wind, or by tacking, a vessel can pass from any one place to any other; and of course in one way or the other she approaches a harbour.

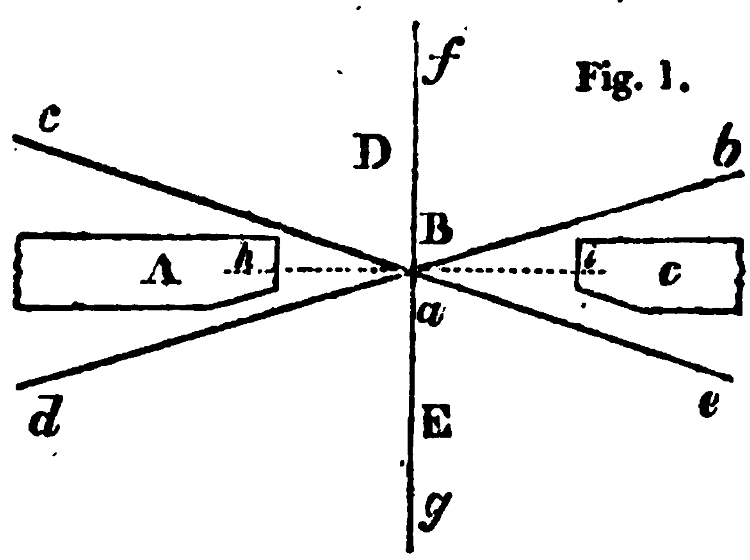


Fig. 1.

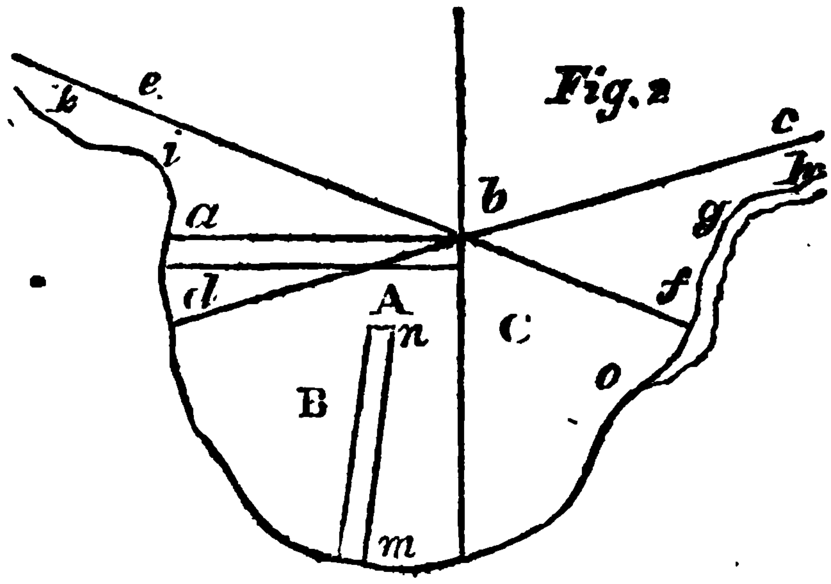
As that entrance which presents itself to the open sea, and admits the surf, can be passed by vessels in all winds; and easier in any wind than the other kind of entrance, I will first treat of it. Let B, fig. 1, be this entrance into the harbour E; D the open sea; A C two piers forming the exterior wall of the harbour; *h i* a line passing through the middle of the piers; and *g a f* another line at right angles to them, and in the middle of the entrance meeting with the line *h i*. Now the wind blowing in the direction *g d* is the most adverse to a ship approaching the entrance B from the open sea; and, as before shown, *b a* and *c a* are the lines of approach for this wind. These lines *b a* and *c a* make an angle of 13 points, or 146° 15′, with each other; and, being the larboard and starboard tacks for the most contrary wind, they have within them all the necessary lines of approach for winds from all points of the compass; and the harbour E having in front of its entrance 13 points, or 146° 15′ of clear sea room, is accessible in any wind whatever.

The directly contrary wind, and winds within a point on each side of it, would be in gales the worst of all to enter with; but, that coming from the adjoining land, they have not space to raise a high sea near the harbour; otherwise a vessel in attempting to enter against a gale out of the harbour-mouth, would, to a certainty, be driven out to sea again.

Vessels passing through entrances of this kind can in all winds take shelter within the pier-heads without any assistance from harbour boats to draw them into the entrance, and in gales from any quarter are not, as in entrances of the other kind, in danger of being driven on the lee shore, provided they are in a good sailing condition and come to the proper place to make the entering tack in side winds. But if vessels arriving in distress by violent storms, by negligence, or want of local knowledge of

the commanders, miss the harbour altogether, the loss in consequence is not chargeable upon the entrance.

Entrances that face the calmest quarter, and that do not receive the surf, are at right angles, or nearly so, to the main shore. Let A, fig. 2, be such an entrance to the harbour B, facing the high shore *o g*; *a b* is the main pier, and *n m* the inner pier. The exterior lines of approach, *e b*, *c b*, are obtained by allowing such space in front of the shore *a t*, *i k*, and *g h*, as will keep ships sailing on these lines from rocks and shallow water; and if they have within them 146° 15′, then a vessel can reach the pierhead *b* in any wind. But as the side *c* is open in strong sea gales, vessels are some times carried too far past the head *b* to turn into the harbour-mouth A; and the same happens in gales out of the harbour-mouth A: vessels so driven aside are forced upon the contiguous rocks or sandy shore, and are destroyed or much injured. So it has happened after an entrance of this kind has been tried to a large harbour, and where money could be obtained, that outworks have been erected on the exposed side *c*, which assimilate the principle of this entrance, when so modified, very closely with that of the first kind of entrance.



I am, Sir, yours, &c.
J. B. Longmire.

Article V.

On the Geology of Devon and Cornwall. By the Rev. J. J. Conybeare, MGS.

(To the Editor of the *Annals of Philosophy.*)

MY DEAR SIR, *Bath Easton, Feb. 2, 1823.*

The notice of such geological travellers as first visited Cornwall and Devonshire was of course most strongly attracted by those which may be termed their metalliferous districts, and these still do and must always continue to present the most immediate and interesting objects of such research. Soon also the attention was directed to such points of the coast as are

distinguished either by the magnificence of their scenery, or the extent of the sections and singularity of the phenomena which they exhibit. Many and valuable as the contributions to the geological history of both counties have unquestionably been, yet our knowledge of their structure (especially in the case of such districts as do not fall under the above-mentioned heads) is by no means so perfect as to preclude even in a casual visitor the hope of adding somewhat of information to the present stock. It may be useful too to point out the deficiencies which yet remain to be supplied by those who have better opportunities and leisure. Such is the object of the following memoranda collected chiefly during the summers of 1809 and 1812, and partly verified in that of 1819. On many points they are of necessity very imperfect, and some parts of the original manuscript have been omitted in consequence of the same phenomena having been far more accurately and fully described in the essay contributed by Mr. Sedgwick to the first part of the Cambridge Philosophical Transactions. What is retained, I have arranged for convenience' sake geologically, rather than topographically; and in this arrangement I venture to propose the following division of the principal rock masses as one which, if not strictly scientific, will yet, I think, be found useful for the purpose.

1. Granite, including some porphyritic beds and mineral veins, and shorl rock.

2. Metalliferous, or, more strictly, cupriferous and stanniferous slate, including various porphyritic and felspathic rocks (elvans), and occasionally greenstone. This I will venture for brevity's sake to term the *inferior slate.*

3. Slate (which I shall venture for the same reason to term *superior*), containing no elvans, but abounding much more in greenstone, especially in its obscurer varieties, and in dark coloured limestones. Sparingly metalliferous, containing no tin, and more productive of lead than the inferior. Contains occasionally organic remains.

4. Stratified rock, exhibiting the general character of a conglomerate or sandstone, alternating with tender slate, and occasionally associated with coralline or shelly limestone. Contains no metallic veins, and few if any rocks of the greenstone species. This rock might, perhaps, be regarded as forming the upper portion of No. 3, and both would probably by most geologists be termed greywacke. As any attempt at restricting that term might produce confusion, I shall venture for the present to term this (No. 4) sand slate.*

* It is, perhaps, almost needless to remind those who are practised in geological research, that the division of slates here adopted is purely arbitrary, and, for convenience, as the inferior do in fact pass by so imperceptible a gradation into the superior as to render it impossible to assign any determinate limits to each variety, however an examination of points distant *inter se* may satisfy us of their characteristic difference. It appears to be pretty generally agreed that such a gradation is observable in most of our schistose ranges.

1. *Granite.*—The character of this rock is, so far as I am acquainted with it, remarkably uniform through the whole extent of its range. That of Waterloo Bridge may serve as a specimen.* Near the points of junction with the incumbent slates, it occasionally becomes small grained, and of a redder hue, resembling the granite of veins. Examples may be found at a junction near Ivy Bridge, at Buckland on the Moor, above Belstone (near Okehampton), and near Bovey Tracey at the spot which produced the fine specimens of tourmaline and apatite. As noticed by Mr. Sedgwick in these cases, there appears to be a diminution, sometimes a total loss, of the mica. The predominant variety of granite contains also in many places patches of a smaller grain, generally of a form more or less spherical. These differ so much in their aspect from the general mass, that, by a casual observer, they might be taken for imbedded portions of another rock; a more accurate inspection will soon show that this is not the case, even in those instances in which (as near St. Just) the predominance of dark coloured mica or chlorite in these patches gives them much the aspect of a kind of gneiss. Other instances may be found near the Land's End, near Moreton Hampstead, above Henoch, and on the road leading from Bovey Tracey to the depot of tourmalines, &c. already mentioned.†

The disintegration of granite *in situ*, as exhibited on a large scale at the porcelain clay pits in St. Stephen's, and the open mine of Carglaise,‡ near St. Austel, has been often noticed. Another large tract of the same character will be found on Dartmoor, in the neighbourhood of a hamlet termed (from the nature of the soil thus produced) Sandy Park. Other partial instances occur, and the granitic tors, the formation of which has been so ably illustrated by Dr. Macculloch, afford abundant proof that the action of the causes which produced this phenomenon has been at some time or other nearly universal.§ It has, I believe,

* See Mr. Sedgwick's paper (p. 10). It may here be noticed that the constituent minerals of granite are seldom found in the west (as in many similar tracts) distinctly or separately crystallized. The *imbedded* crystals of felspar have been noticed by Mr. S. and others. I found it crystallized in rhombs in small cavities on St. Michael's Mount, and in small rhombs and in larger crystals of a more complicated form at the tourmaline pit near Bovey Tracey. I have also from Cornwall, but without the exact locality, two specimens of perfectly crystallized mica, the one a rhomboidal, the other an hexagonal tablet. Both are in a small grained reddish granite (possibly an elvan), the aspect of which does not resemble that of the specimens brought from Scilly by Mr. Majendie. I may add, that on St. Michael's Mount, I observed in a highly felspathic portion of the granite insulated crystals of felspar rendered as tender as the softest clay by some process of decomposition which had not affected the imbedding mass.

† Mr. Sedgwick mentions the same phenomenon as observable near Castle Trereen (the Logging Rock): to his remarks I would refer the student for much fuller information.

‡ It is, perhaps, hardly worth while to state, that the finest porcelain clay which I obtained in Cornwall was from a vein in Carglaise. It occurred in very small quantities.

§ Mr. Taylor (Report, p. 1) affords an interesting illustration of one result of this process. "If the ground, 80 fathoms south-east of Carn-brae, and at Wheal Druid, had not been penetrated by the mines, it is very possible that the whole of it extending

been noticed, that these disintegrated tracts exhibit frequent patches of various dimensions retaining their original compactness. It would be a point of some geological interest to ascertain, as accurately as circumstances permit, the extent to which this disintegration actually obtains, and to enquire whether the tracts in question exhibit any phenomena which might guide our speculations as to its probable cause. That that cause is not to be sought in the mere superficial action of weather and moisture, we may, I think, argue from the great depth to which (as at Carglaise) the disintegration is found to extend. I have heard it suggested, that this state of granitic rocks is to be regarded rather as the mode of their original formation than as the result of causes acting subsequently. This hypothesis, however, seems hardly reconcileable to the appearances presented by Carglaise. Some may, perhaps, incline to view the phenomenon as analogous to the disintegration which is known to obtain largely in crystalline rocks forming acknowledged dykes,* and to these it may appear to countenance the theory which attributes to granite an igneous origin. At all events, this species of decomposition seems for the most part peculiar to rocks of a crystalline structure. In some cases, if my observation be correct, the granite is traversed by porphyritic dykes, or elvans, similar to those occurring in the slate. I noticed one (in company with Mr. Buckland) in 1812 on the summit of Kitt Hill, near Callington. In some cases too the saalbande, or wall of metalliferous veins traversing the granite, appears to be of this class. At Bean Mine, about one mile east of Roche, the surrounding *country* is granite of the usual aspect; while the walls of the tin lode which are of considerable thickness have all the character of an elvan dyke, the paste of which is chiefly quartzose with a mixture of mica, talcite, felspar much disintegrated, and crystallized shorl, the tin occurring in veins with shorl towards the centre of this elvan (the veins occasionally send out small lateral branches at various angles), the elvan itself is said to dip three feet in the fathom, and in its general character much resembles some of those found to the east of St. Agnes. The same inclusion (if I may so term it) of a metallic vein by a rock differing from the surrounding granite I recollect to have noticed also at Newbridge, and in the Gwennap cluster. It would be desirable to

to a much greater distance from the top of the hill, would have been taken to be granite, as the surface has every appearance of a growan soil intermixed with granite stones and rocks plentifully scattered about. The same has been observed on the sides of Carn Marth and other granite hills bordering on the Killas country." We were assured that at Newbridge they had sunk above the granite country in a mass of granitic rubble with occasional blocks of killas intermixed to the depth of nearly 30 yards, and above the killas country in a rubble of that rock with a small admixture of killas to about half that depth.

* See Mr. Henslow's Account of Anglesea. (Cambridge Philosophical Transactions, Part II.)

ascertain how far this is the case in veins which traverse granite.

At Kit Hill above-mentioned, at Carglaise, and at some other places, we were assured by miners apparently of competent information, that the granite did in some places overlie the killas. In these instances, it is possible that granitic dykes may have been mistaken for the central mass, or that our informants might have been misled by some of those deceptive appearances which are familiar to most geologists. Mr. Taylor, in his excellent Survey of the Mining District, mentions an analogous fact, and his observation is too important to be omitted. "In Dolcoath and five other mines situate near the junction, the strata of granite and killas *appear alternately overlying each other*, the divisions between them being at various inclinations;* but sufficient information cannot be obtained to state with accuracy the particulars."†

On the subject of granitic veins, my memoranda afford nothing which can add to the copious and masterly observations of Mr. Sedgwick. I may mention, however, that the country near the junctions of Carn-brae, of Kit Hill, of the upper part of the river Okement, and of some other spots of the same character,‡ will afford the collector hand specimens well calculated to illustrate on a small scale many of the phenomena which present themselves so fully and magnificently at the cliffs of Trewavas and Polmear.

It may here be noticed, that the mineral substances confined to the granite (or rather not yet discovered in the superincumbent rocks also), are few in number. Apatite, pinite, andalusite, and, I believe, uranite, at present complete the list.

Shorl Rock.—This binary compound, too generally known to need any description here, is usually found on the confines of the granite in such large masses as to render us doubtful what name to assign to them. Indeed our geological guides have not as yet furnished us with a very definite or accurate terminology for the purpose. What one observer would describe as a large dyke or patch, another would, perhaps, elevate to the dignity of a formation. Roche has been constantly noticed as presenting a magnificent display of this rock; and Mr. Sedgwick mentions it as occurring in veins traversing the granite between Lemorna Cove and the Land's End (p. 19). I have observed it on the large scale forming the whole of the tor named Carn Mewan,

* Therefore, if there is any parallelism in the stratification of the killas, the granite must be considered not as an alternation but a vein. At Dolcoath, the floor of granite is said to be nearly horizontal; most of the killas in the neighbourhood is, if I do not err, considerably inclined. (See Thomas's Report, p. 34.)

† Mr. Sedgwick appears to have determined this point as far as our present means of examination permit. (P. 34.)

‡ We obtained some highly illustrative at Costellow's Mine, near Roche.

near St. Austle, and of another tor (the name of which I have lost), overtopping the upper road, which leads to Buckland on the Moor. If my memory does not fail me, I observed it on a scale equally large in more than one other spot on the Cornish Downs, and on Dartmoor; but I either neglected to mark at the time, or have since mislaid the exact localities. I would venture to recommend to the examination of future tourists two points connected with this rock.

1. Whether some other of the tors on the confines of the granitic tracts (besides those specified) do not consist of shorl rock. From its external configuration and neighbourhood to the granite, it may be easily confounded with that rock until examined more closely.

2. Is it possible from the careful examination of the country surrounding Roche Rocks, to ascertain whether that remarkable eminence has been produced by the disintegration and washing away of some less durable beds which once enveloped it? or whether it may be regarded as an original inequality of surface?*

Most of the varieties of external appearance produced in this rock by the different modes of aggregation, have been enumerated by Mr. Sedgwick (p. 18). To his list, I am enabled to add, as Nos. 5 and 6,

5. Alternate layers generally of great tenuity, of very minutely granular quartz and shorl, having all the aspect of a stratified mass.

6. Real or pseudo breccia consisting of small patches of compact shorl imbedded in quartz, or *vice versâ* of quartz imbedded in shorl.

These varieties occur in the neighbourhood of the crystalline and more predominant form. No. 5 appears to offer another exemplication of a law, which I believe to obtain pretty generally, "that crystalline rocks when they occur in large masses are most usually accompanied by schistose rocks composed of the same mineral ingredients in a state of greater alternation." To the verification of this law, I would venture to solicit the attention of those who join a knowledge of mineralogy and chemistry to that of geology. The establishment of its probability might lead to some important theoretical results. Nor should I omit to mention, that the varieties of shorl rock above noticed are peculiarly interesting from the examples which they afford, even in hand specimens, of the various phenomena of configuration incident to rocks of the schistose character. The marked distinction of colour and aspect existing between the two constituents (tourmaline and quartz) render these very striking and intelligible. Even the very small collection which I possess myself, offers within the scale of a few inches highly instructive examples of contortion, dislocation, crossing, and

* I would suggest a like examination of two singularly insulated masses of rock occupying opposite sides of a ravine near Camelford, known by the name of the Devil's Leap.

heaving of veins. Neither this, however, nor my observations, are sufficiently extensive to justify the theorizing, with any confidence, on the subject. As far as I can conjecture, the appearances offered by my own specimens would be most readily accounted for by an hypothesis which should admit, 1. That the laminated arrangement of the rock is not in all cases the result of successive depositions. 2. That disturbances have taken place subsequently to the formation and contortion (if these be not synchronous) of the laminæ. 3. That at the period of these disturbances, the degree of consolidation varied in different portions of the mass. I would, however, conclude by strongly recommending this rock to the more accurate examination of future travellers; and am, dear Sir, very truly yours,

J. J. CONYBEARE.

ARTICLE VI.

On Hatchetine. By the Rev. J. J. Conybeare, MGS.

(To the Editor of the *Annals of Philosophy.*)

MY DEAR SIR, *Bath Easton, Feb.* 10, 1823.

I HASTEN to acknowledge that a perusal of Mr. Brande's elementary work on Chemistry (which has only of late fallen into my hands), has shown me that I have been anticipated by that gentleman in the examination of the mineral substance which I ventured to name *hatchetine,* and which is enumerated by him under the varieties of bitumen, as *mineral adipocire.* Mr. Brande's work was published, I believe, early in 1821. My own experiments, made the autumn before, were transcribed for the *Annals* in the January of that year. Strictly, therefore, I have to apologize to your readers only for the second of my communications (the short note appended to the examination of mumia), which an earlier perusal of Mr. Brande's work would certainly have caused me to suppress. Allow me to express my satisfaction, that the examination of the substance in question has fallen into better hands than my own; and that my opinion as to its specific difference from every other known variety of bitumen is corroborated by so competent an authority. With Mr. Brande's permission, however, I would still contend for the superior propriety of the name hatchetine, both for the reason formerly assigned, and from the feeling that it is rather desirable to banish from our nomenclature all such *significant* names as are not indicative of some actual property of the substance to which they are applied.

Believe me, dear Sir, very truly yours,

J. J. CONYBEARE.

ARTICLE VII.

Results of a Meteorological Register kept at New Malton, Yorkshire, in the Year 1822. By Mr. J. Stockton.

1822.	Barometer.						Thermometer.				Winds.											Weather.			Rain.
	Maximum.	Minimum.	Mean.	Range.	Spaces described in inches and parts.	Number of changes.	Maximum.	Minimum.	Mean.	Range.	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Variable.	Brisk.	Boisterous.	Rainy days.	Snow.	Hail.	Inches, &c.
January ...	30·27	29·10	29·870	1·17	6·38	17	50°	30°	38·677°	20°	3	2	1	0	0	7	10	6	2	1	1	9	1	0	2·36
February...	30·70	28·25	29·784	2·45	11·69	19	54	29	40·714	25	1	0	0	0	7	11	5	2	2	4	4	7	0	0	1·70
March.	30·30	28·80	29·687	1·50	10·13	17	60	29	44·516	31	1	0	0	1	4	13	8	4	0	9	3	9	3	3	3·81
April......	30·34	28·95	29·720	1·39	5·50	10	63	32	46·585	31	4	5	2	6	5	1	3	3	1	5	2	10	1	5	2·73
May	30·35	29·30	29·857	1·05	5·73	16	74	37	53·822	37	0	15	7	0	0	2	2	0	5	2	1	5	0	0	3·36
June	30·17	29·50	29·938	0·67	4·64	15	84	42	61·583	42	6	7	2	2	0	2	2	1	8	1	0	6	0	0	2·40
July	29·87	29·10	29·514	0·77	5·71	15	71	44	59·984	27	3	4	3	3	0	5	3	3	7	0	0	22	0	0	6·00
August	30·10	29·02	29·616	1·08	4·89	13	75	44	59·645	31	0	3	1	2	3	13	3	2	4	3	1	13	0	0	3·60
September..	30·20	29·09	29·764	1·11	5·76	14	68	42	53·633	26	11	7	0	0	0	12	0	0	0	6	1	4	0	0	0·67
October....	29·90	28·92	29·396	0·98	7·21	19	63	34	49·209	29	2	2	2	2	12	7	2	1	1	6	4	14	0	0	4·32
November..	30·06	28·51	29·360	1·55	8·58	25	59	30	43·950	29	0	0	0	3	10	13	0	2	2	9	7	20	0	0	3·87
December..	30·65	28·05	29·935	2·60	9·63	15	45	25	34·500	20	1	6	5	6	0	8	1	2	2	2	3	6	0	0	1·28
Annual means, &c.	30·70	28·05	29·703	2·65	85·85	195	84	25	48·901	59	32	51	23	25	41	94	39	26	34	48	27	125	5	8	37·10

ANNUAL RESULTS.

Barometer.

	Inches.
Highest observation, Feb. 27. Wind, NW.	30·700
Lowest observation, Dec. 5. Var. and tempestuous	28·050
Range of the mercury	2·650
Mean annual barometrical pressure	29·703
Greatest range of the mercury in December	2·600
Least range of the mercury in June	0·670
Mean annual range of the mercury	1·360
Spaces described by the mercury	85·850
Total number of changes in the year	195·000

Six's Thermometer.

Greatest observation, June 5. Wind, variable	84·000°
Least observation, Dec. 28. Wind, SE.	25·000
Range of the mercury in the thermometer	59·000
Mean annual temperature	48·901
Greatest range in June	42·000
Least range in January and December	20·000
Mean annual range	29·000

Winds.

	Days.
North and East	55·000
North-east and South-east	76·000
South and West	80·000
South-west and North-west	120·000
Variable	34·000

Rain.

	Inches.
Greatest quantity in July	6·000
Least quantity in December	1·280
Total amount for the year	37·100

Observations.

Pressure.—The greatest range of the mercury, which is nearly that for the year, took place in December, and notwithstanding the amount of rain, the spaces described in inches, and the number of changes in the direction of the column, are less than usual; while the mean is higher than for some time past.

Temperatures.—The mean temperature for the year just elapsed is 1° higher than that of the preceding one. The months of April, May, August, September, and December, were considerably warmer in 1821 than the corresponding ones of last year; while the three first months, and June and July, are as much the reverse. The means of October and November in both periods are nearly alike.

Rain.—The amount of rain exceeds that of last year upwards of eight inches, and is the wettest we have had since 1816. The greatest monthly quantity fell in July, attended on five successive days with most tremendous thunder and lightning.

I am, Sir, your most obedient servant,

New Malton, Feb. 5, 1823. J. STOCKTON.

ARTICLE VIII.

On Hannibal's Passage through the Alps. By Thomas M'Keever, MD.

(To the Editor of the *Annals of Philosophy.*)

SIR,

HARDLY any passage in the writings of Livy has been more frequently the subject of comment than that in which Hannibal is stated, during his celebrated and interesting march through the Alps, to have effected the removal of a large cliff, which impeded the progress of his army, by means of the joint agency of fire and vinegar.

As the particulars of this very remarkable event may have escaped the recollection of some of your readers, it may not be amiss to mention a few of the leading circumstances. Livy informs us that Hannibal having, after a series of the most frightful difficulties and dangers, reached the summit of the Alps, rested there two days, in order to recruit his exhausted troops: that he then commenced his descent, but had not proceeded far, when he came to a projecting cliff of great height, which completely obstructed his further progress. Having in vain searched for a more convenient route, he at length determined on levelling this formidable barrier, and for this purpose ordered a number of large trees to be felled, and placed in a pile at its base: they were then set on fire, and in a short time (the wind proving favourable), so intense was the action of the heat, that the solid rock became as red as the blazing fuel with whch, it was surrounded. Hannibal now thought of applying a quantity of vinegar to its surface, which, it is asserted, had the effect of softening its substance, and in this way a passage was spee-

dily opened, by which his army with their elephants and baggage were enabled to proceed.

Some writers have contended that the action of the acid was the principal, if not the sole agent in producing the effect here described; others suppose that the solid rock was actually fused, by the intense action of the fire on its surface; while another set of commentators, from the difficulties attendant on its explanation, consider the whole statement as an idle fabrication, for which the author had no foundation whatever. As, however, the entire process may, I conceive, be explained on plain and obvious principles, I can see no necessity for calling in question the accuracy of a writer, who "for probity, candour, and impartiality, has been so much distinguished above every other historian." The difficulty of procuring in those wild retreats a sufficient number of trees for making a huge pile such as Livy describes, has been advanced as one of the principal objections to the statement of this historian. We are to consider, however, that although this objection might apply to the very summit of the Alps, where vegetation is nearly, if not altogether, suspended: it is by no means applicable to the sides or skirts of those mountains, which all travellers, and among the rest Polybius, agree in describing, as being in several places clothed with large woods. We are also to bear in mind, that the various passes through those sequestered regions, run, not across the ridges or summits of the mountains, as some have supposed, but that they are conducted through many defiles, and were probably traced out by paths that have served from time immemorial, as means of communication between the fertile valleys that lie interspersed up and down the windings of this immense chain.* Now as it can be satisfactorily proved, from the testimony of the two principal historians who have recorded this memorable march, that Hannibal never reached the very summit of those dreary solitudes, but that he merely ascended to the top of one of the lesser ridges, it is obvious that he could have had no difficulty in procuring any quantity of fuel that he might have required. In proof that Hannibal never attained the summit of the Alps, it may be observed that Polybius and Livy, although they differ materially as to the route which the Carthaginian general took, agree in stating, that, having completed his ascent, he conducted his troops, exhausted and broken down with the innumerable hardships they had encountered, to a convenient spot, where he pointed out to them the rich and fertile plains of Italy as the reward of all their toils and privations;† but had Hannibal ascended to the upper range of the Alps, it is altogether impossible he could have indulged his army with such a cheering prospect; lesser mountains would have intercepted their view; and instead of smiling luxuriant plains, an immeasur-

* See Eustace's Classical Tour through Italy, vol. i. p. 12.
† See Hook's Roman History, vol. ii. p. 126.

able expanse of desolation must have met the eye. Besides, it may be asked, is it at all probable that Hannibal, while traversing an unknown and savage region, where every object, clothed with the dread magnificence of heaven, was calculated to excite feelings of astonishment and terror,* would attempt to deviate from the ordinary passes pointed out to him by experienced guides: he must have felt convinced that inevitable destruction would be the consequence of such a rash unjustifiable proceeding.

The improbability of Hannibal having at hand a sufficiency of vinegar to effect the decomposition of the rock, has also been brought forward as an insurmountable objection to Livy's account of this achievement. Although I am fully satisfied that the action of the vinegar had no share whatever in accomplishing the destruction of the cliff, still I see no absurdity in supposing that a Carthaginian army should have been supplied with a considerable quantity of this liquid. Several historians inform us, that, from a very early period, vinegar and water constituted almost the sole drink of the military during their long and fatiguing marches: thus Cæsar, on one occasion, while conducting his troops through the Alps for the purpose of encountering a branch of Pompey's army, then in Spain, under the command of Afranius and Petreius, is described as having supported them for several days, principally by means of this simple beverage; and Crevier, in his History of the Roman Emperors, tells us, "that the Emperor Severus had altogether proscribed the use of wine, which had for some time crept in among his soldiers, and reduced them to vinegar and water, which formed the common drink of the military in ancient times."

Having thus briefly stated such arguments as have occurred to me in support of the credibility of Livy's statement, I proceed to explain in what manner I conceive this important undertaking to have been accomplished.

Water, it is well known, will insinuate itself into the minute pores and crevices of the most solid bodies, and being expanded by variations of temperature, is capable either of rending them asunder, or of detaching portions from their surface. Expansion, as is well known, may take place in this liquid from two opposite causes, an increase or a diminution of temperature; that very remarkable enlargement of volume which water undergoes during congelation, is capable of producing very powerful effects, and enables us to explain a number of interesting phenomena. The

* Nullum ver usquam, nullique æstatis honores;
Sol jugis habitat diris, sedesque tuetur
Perpetuus deformis hyems; illa undique nubes
Huc atras agit et mixtos cum grandine nimbos.
Jam cuncti flatus, ventique furentia regna
Alpina posuere domo, caligat in altis
Obtutus saxis, abeuntque in nubila montes.
(Sil. Ital. lib. 3.)

Florentine academicians were enabled to burst a brass globe, the cavity of which was an inch in diameter, by means of this expansive power, and calculating from the tenacity of brass, and the thickness of the sides of the globe, this must have required a force exceeding 27,720 pounds.* Vast masses of rock are from this cause frequently detached from the cliffs, and precipitated with great velocity into the adjoining valleys. The rending of trees in northern latitudes during the winter months, the bursting of water pipes, the raising of pavements, the increased fertility of the soil after frost (owing to the facility with which the delicate fibres of the roots of plants are enabled to extend themselves), may all be referred to the same principle. The expansion which water undergoes at elevated temperatures is, however, still more considerable, and is capable of producing the most astonishing effects. When heated to 212° of Fahrenheit, at the mean pressure of the atmosphere, it becomes converted into steam, an elastic substance, the bulk of which, even at that temperature, is about 1800 times that of the water from which it originated. When heated beyond this point, vapour is expansible to a wonderful degree. Count Rumford ascertained by incontrovertible experiments, that its elasticity became doubled by every addition of temperature, equal to 30° of Fahrenheit's scale. With the heat of $212 + 30 = 242$, its elasticity he found equal to the pressure of two atmospheres; at the temperature of $242 + 30 = 272$, it will be equal to four atmospheres, and so on.† When suddenly generated, this powerful agent is capable of producing the most violent, and at times the most destructive effects. Thus instances ‡ have occurred, where, in consequence of a person carelessly spitting into a copper foundry, the entire building has been destroyed, and even when the moulds contain the slightest moisture, the melted metal is driven back with a loud report, and is violently dispersed in every direction. A drop of water also by falling into a vessel of boiling linseed oil, where it became instantly converted into vapour, has been known to produce the most violent explosions. On this principle then, namely, that of sudden expansion, I conceive the whole process admits of explanation. The minute, but numerously interspersed globules of water, which had for ages been percolating through the pores and fissures of the rock, undergoing, by the application of a large fire to its base, a sudden enlargement of volume in a short time acquired such a degree of expansive energy as to burst asunder the strong confines by which they had so long been surrounded. Now were Hannibal, while the fire was imparting

* See Murray's Chemistry, vol. i. p. 250.

† The elastic force of steam does not increase in quite so rapid a progression as Count Rumford affirms; according to the late experiments of Dr. Ure, it is equal only to 53·6 inches of mercury at 242°, and to about 89 only at 272°.—(See Philosophical Transactions, 1818, or *Annals*, vol. xiii. p. 215.)—*Edit.*

‡ See Black's Lectures, vol. i.

this energetic influence to the particles of confined moisture, to apply a quantity of vinegar to the surface of the rock, there would surely be nothing unnatural in his attributing at least a part of the effect to the liquid he employed, particularly when we take into account the very low state of chemical knowledge, in those early ages, even among men of science.

A phenomenon of annual occurrence in the Polar Seas, bears, I conceive, considerable analogy to the point we have been discussing, and appears to me to confirm the explanation I have ventured to advance; I allude to the frequent disruptions, or icequakes, as they are termed, which take place among the icebergs, on the return of the summer season. In those remote latitudes, as soon as the long and dreary winter has passed away, the hot weather sets in with unusual rapidity, in consequence of which the numerous globules of air, that had been incased in those vast accumulations, soon begin to expand,* and struggling, as it were, for liberty, in a short time acquire such irresistible force as to occasion the disseveration of the mountain. In this way large masses separate, and are precipitated into the ocean with a tremendous noise, not unlike that of a distant peal of thunder. Volcanic eruptions, explosions in coal mines, and several other phenomena, together with the common operation of blasting, might likewise be adduced to prove the wonderful power possessed by elastic fluids, whether in the form of vapour, or of gas, when exposed to high temperature; but to enlarge upon a principle now so well understood, and so extensively applied, appears altogether unnecessary.

Article IX.

On the Presence of Oil in the Serum of the Blood. By Thomas Stewart Traill, MD.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Liverpool, Royal Institution, Jan.* 10, 1823.

Upwards of two years ago, I detected the presence of a considerable proportion of oil in the serum of the blood of a man labouring under internal inflammation; and a second attack of decided hepatitis in the same individual afforded me another opportunity of verifying the observation in the spring of 1821. These facts were communicated to the public in the 17th volume of the Edinburgh Medical and Surgical Journal. In both instances, the singularly *white* colour of the serum induced the

* See Leslie on Heat and Moisture.

chemical examination; and a similar appearance having recently occurred in a case under the care of my friend Dr. M'Cartney, of this place, he sent to me a portion of the serum, which yielded on analysis a still larger proportion of oil than had been obtained in the former instances. Dr. M'Cartney's patient is a stout young man, who was attacked by acute hepatitis.

Examination of the Serum.

This serum separated spontaneously from the crassamentum; but in appearance, it strikingly resembled that described in the journal above-mentioned. Its colour is a fine yellowish-white; its consistence (in this cold weather) is that of very thick, rich, cream; but it becomes more fluid by a gentle heat. It did not make any deposit, on being left at rest for several weeks. Indeed serum of this sort seems little disposed to spontaneous change; for some which has been two years in my possession still retains its colour; and though it has a putrid smell, it exhibits visible signs of decomposition only by a very slight separation of nearly colourless water, from a coagulum resembling new cheese.

The specific gravity of the serum now under consideration = 1·0187, which nearly agrees with that last examined, though it be somewhat less than that of the first.

One hundred grains of the serum were slowly evaporated by a moderate temperature. The residue, when the watery part was wholly dissipated, = 21·1 grs. A yellowish transparent oil was observed to flow beneath the solid residue, when the glass capsule was heated; but it became solid, and of a greyish-white colour, at the ordinary temperature of my apartment. The oil was taken up, while fluid, by bibulous paper, which had been previously weighed with due attention to ensure uniformity in the state of its hygrometric moisture. A portion of the paper was deeply stained with the oil, and fresh portions were employed until the broken coagulum no longer soiled the paper. The weight gained by the paper = 4·5 grains.

The albumen was soaked for six hours in distilled water, and well washed on a filter. The dried albumen = 15·7 grains. The washings were evaporated, and saline matter, consisting chiefly of muriates and lactates, were obtained, amounting to 0·9 gr. of which 0·7 appeared to be of the former.

From these results, we may state the constituents of this remarkable fluid to be:

Water	=	78·9
Albumen	=	15·7
Oil	=	4.5
Salts	=	0·9
		100·0

The peculiarities of this serum consist in its containing oil, which exists in the form of an *emulsion*, and in this case amounts to $4\frac{1}{2}$ per cent.; in its having about double the usual quantity of albumen assigned to the serum of blood by the experiments of Berzelius and others; and in its diminished proportion of saline ingredients. It is worthy of remark, that these peculiarities in the three cases were connected with inflammatory disease; and in the two last were accompanied by decided inflammation of the liver. I have had an opportunity of examining the blood of one of the patients when he was in health, and found nothing peculiar in it. I may also state, that I examined some time ago a serum which resembled, in colour and consistence, thin *water-gruel*; but in this I could detect no oil; and it seemed to owe its peculiarities to an excess of albumen.

I am, respectfully yours,
THOMAS STEWART TRAILL.

ARTICLE X.

On the Alloys of Steel. By J. Stodart, Esq. FRS. and Mr. M. Faraday, Chemical Assistant in the Royal Institution.*

THE alloys of steel made on a small scale in the laboratory of the Royal Institution proving to be good, and the experiments having excited a very considerable degree of interest both at home and abroad, gave encouragement to attempt the work on a more extended scale, and we have now the pleasure of stating, that alloys similar to those made in the Royal Institution, have been made for the purpose of manufacture; and that they prove to be, in point of excellence, in every respect equal, if not superior, to the smaller productions of the laboratory. Previous, however, to extending the work, the former experiments were carefully repeated, and to the results were added some new combinations, namely, steel with palladium, steel with iridium and osmium, and latterly, steel with chromium. In this last series of experiments, we were particularly fortunate, having, by practice, acquired considerable address in the management of the furnaces, and succeeded in procuring the best fuel for the purpose. Notwithstanding the many advantages met with in the laboratory of the Royal Institution, the experiments were frequently rendered tedious from causes often unexpected, and sometimes difficult to overcome; among these, the failure of crucibles was, perhaps, the most perplexing. We have never

* From the Philosophical Transactions for 1822. Part II.

yet found a crucible capable of bearing the high degree of temperature required to produce the perfect reduction of titanium; indeed we are rather disposed to question whether this metal has ever been so reduced: our furnaces are equal* (if any are) to produce this effect, but hitherto we have failed in procuring a crucible.

The metals that form the most valuable alloys with steel are silver, platina, rhodium, iridium, and osmium, and palladium; all of these have now been made in the large way, except indeed the last named. Palladium has, for very obvious reasons, been used but sparingly; four pounds of steel with 1-100th part of palladium, has, however, been fused at once, and the compound is truly valuable, more especially for making instruments that require perfect smoothness of edge.

We are happy to acknowledge the obligations due from us to Dr. Wollaston, whose assistance we experienced in every stage of our progress, and by whom we were furnished with all the scarce and valuable metals; and that with a liberality which enabled us to transfer our operations from the laboratory of the chemist, to the furnace of the maker of cast steel.

In making the alloys on a large scale, we were under the necessity of removing our operations from London to a steel furnace at Sheffield; and being prevented by other avocations from giving personal attendance, the superintendence of the work was consequently intrusted to an intelligent and confidential agent. To him the steel, together with the alloying metals in the exact proportion, and in the most favourable state for the purpose, was forwarded, with instructions to see the whole of the metals, and nothing else, packed into the crucible, and placed in the furnace, to attend to it while there, and to suffer it to remain for some considerable time in a state of thin fusion, previous to its being poured out into the mould. The cast ingot was next, under the same superintendence, taken to the tilting mill, where it was forged into bars of a convenient size, at a temperature not higher than just to render the metal sufficiently malleable under the tilt hammer. When returned to us, it was subjected to examination both mechanical and chemical, as well as compared with the similar products of the laboratory. From the external appearance, as well as from the texture of the part when broken by the blow of the hammer, we were able to form a tolerably correct judgment as to its general merits; the hardness, toughness, and other properties, were further proved by severe trials, after being fashioned into some instrument, or tool, and properly hardened and tempered.

It would prove tedious to enter into a detail of experiments made in the Royal Institution; a brief notice of them will at present be sufficient. After making imitations of various speci-

* We have succeeded in fusing in these furnaces rhodium, and also, though imperfectly, platina in crucibles.

mens of meteoric iron by fusing together pure iron and nickel, in proportions of 3 to 10 per cent. we attempted making an alloy of steel with silver, but failed, owing to a superabundance of the latter metal; it was found, after very many trials, that only the 1-500th part of silver would combine with steel, and when more was used, a part of the silver was found in the form of metallic dew lining the top and sides of the crucible; the fused button itself was a mere mechanical mixture of the two metals, globules of silver being pressed out of the mass by contraction in cooling, and more of these globules being forced out by the hammer in forging; and further, when the forged piece was examined, by dissecting it with diluted sulphuric acid, threads or fibres of silver were seen mixed with the steel, having something of the appearance of steel and platina when united by welding; but when the proportion of silver was only 1-500th part, neither dew, globules, nor fibres, appeared, the metals being in a state of perfect chemical combination, and the silver could only be detected by a delicate chemical test.

With platina and rhodium, steel combines in every proportion; and this appears also to be the case with iridium and osmium; from 1 to 80 per cent. of platina was perfectly combined with steel, in buttons of from 500 to 2000 grains. With rhodium, from 1 to 50 per cent. was successfully used. Equal parts by weight of steel and rhodium gave a button, which, when polished, exhibited a surface of the most exquisite beauty: the colour of this specimen is the finest imaginable for a metallic mirror, nor does it tarnish by long exposure to the atmosphere: the specific gravity of this beautiful compound is 9·176. The same proportion of steel and platina gave a good button, but a surface highly crystalline renders it altogether unfit for a mirror. In the laboratory, we ascertained that, with the exception of silver, the best proportion of the alloying metal, when the object in view was the improvement of edge tools, was about 1-100th part, and in this proportion they have been used in the large way. It may be right to notice, that in fusing the metals in the laboratory no flux whatever was used, nor did the use of any ever appear to be required.

Silver being comparatively of little value with some of the alloying metals, we were disposed to make trial with it as the first experiment in the large way: 8 lbs. of very good Indian steel was sent to our agent, and with it 1-500th part of pure silver: a part of this was lost owing to a defect in the mould; a sufficient quantity was, however, saved, to satisfy us as to the success of the experiment. This, when returned, had the most favourable appearance both as to surface and fracture; it was harder than the best cast steel, or even than the Indian wootz, with no disposition whatever to crack, either under the hammer, or in hardening. Some articles for various uses have been made from this alloy; they prove to be of a very superior quality; its application will probably be

extended not only to the manufacture of cutlery, but also to various descriptions of tools; the trifling addition of price cannot operate against its very general introduction. The silver alloy may be advantageously used for almost every purpose for which good steel is required.

Our next experiment made in the large way was with steel and platina: 10 lbs. of the same steel, with 1-100th part of platina, the latter in the state produced by heating the ammonia muriate in a crucible to redness, was forwarded to our agent, with instructions to treat this in the same way as the last named metals. The whole of this was returned in bars remarkable for smoothness of surface and beauty of fracture. Our own observation, as well as that of the workmen employed to make from it various articles of cutlery, was, that this alloy, though not so hard as the former, had considerably more toughness: this property will render it valuable for every purpose where tenacity, as well as hardness, is required; neither will the expense of platina exclude it from a pretty general application in the arts; its excellence will much more than repay the extra cost.

The alloys of steel with rhodium have also been made in the large way, and are, perhaps, the most valuable of all; but these, however desirable, can never, owing to the scarcity of the metal, be brought into very general use. The compound of steel, iridium, and osmium, made in the large way, is also of great value; but the same cause, namely, the scarcity and difficulty of procuring the metals, will operate against its very general introduction. A sufficient quantity of these metals may, perhaps, be obtained to combine with steel for the purpose of making some delicate instruments, and also as an article of luxury, when manufactured into razors. In the mean time, we have been enabled, repeatedly, to make all these alloys (that with palladium excepted), in masses of from 8 to 20 lbs. each; with such liberality were we furnished with the metals from the source already named.

A point of great importance in experiments of this kind was to ascertain whether the products obtained were exactly such as we wished to produce. For this purpose, a part of each product was analysed, and in some cases the quantity ascertained; but it was not considered necessary in every case to verify the quantity by analysis, because, in all the experiments made in the laboratory, the button produced after fusion was weighed, and if it fell short of the weight of both metals put into the crucible, it was rejected as imperfect, and put aside. When the button gave the weight, and on analysis gave proofs of containing the metal put in to form the alloy, and also on being forged into a bar, and acted on by acids, presented an uniform surface, we considered the evidence of its composition as sufficiently satisfactory. The processes of analysis, though simple, we shall briefly state; the information may be desirable to others who

may be engaged on similar experiments; and further, may enable every one to detect any attempt at imposition. It would be very desirable at present to possess a test as simple, by which we could distinguish the wootz, or steel of India, from that of Europe; but this, unfortunately, requires a much more difficult process of analysis.

To ascertain if platina is in combination with steel, a small portion of the metal, or some filings taken from the bar, is to be put into dilute sulphuric acid; there will be rapid action; the iron will be dissolved, and a black sediment left, which will contain carbon, hydrogen, iron, and platina; the carbon and hydrogen are to be burnt off, the small portion of iron separated by muriatic acid, and the residuum dissolved in a drop or two of nitro-muriatic acid. If a piece of glass be moistened with this solution, and then heated by a spirit-lamp and the blowpipe, the platina is reduced, and forms a metallic coating on the glass.

In analysing the alloy of steel and silver, it is to be acted on by dilute sulphuric acid, and the powder boiled in the acid; the silver will remain in such a minute state of division, that it will require some time to deposit. The powder is then to be boiled in a small portion of strong muriatic acid;* this will dissolve the iron and silver, and the latter will fall down as a chloride of silver on dilution with water; or the powder may be dissolved in pure nitric acid, and tested by muriatic acid and ammonia.

The alloy of steel and palladium, acted on by dilute sulphuric acid, and boiled in that acid, left a powder which, when the charcoal was burnt from it, and the iron partly separated by cold muriatic acid, gave on solution in hot muriatic acid, or in nitro-muriatic acid, a muriate of palladium; the solution, when precipitated by prussiate of mercury, gave prussiate of palladium; and a glass plate moistened with it and heated to redness, became coated with metallic palladium.

The residuum of the rhodium alloy obtained by boiling in diluted sulphuric acid, had the combustible matter burnt off, and the powder digested in hot muriatic acid: this removed the iron; and by long digestion in nitro-muriatic acid, a muriate of rhodium was formed, distinguishable by its colour, and by the triple salt it formed with muriate of soda.

To analyze the compound of steel with iridium and osmium, the alloy should be acted on by dilute sulphuric acid, and the residuum boiled in the acid; the powder left is to be collected and heated with caustic soda in a silver crucible to dull redness for a quarter of an hour, the whole to be mixed with water, and having had excess of sulphuric acid added, it is to be distilled,

* Although it is a generally received opinion, that muriatic acid does not act on silver, yet that is not the case; pure muriatic acid dissolves a small portion of silver very readily.

and that which passes over condensed in a flask: it will be a solution of oxide of osmium, will have the peculiar smell belonging to that substance, and will give a blue precipitate with tincture of galls. The portion in the retort being then poured out, the insoluble part is to be washed in repeated portions of water, and then being first slightly acted on by muriatic acid to remove the iron, is to be treated with nitro-muriatic acid, which will give a muriate of iridium.

In these analyses, an experinced eye will frequently perceive, on the first action of the acid, the presence of the alloying metal. When this is platina, gold, or silver, a film of the metal is quickly formed on the surface of the acid.

Of alloys of platina, palladium, rhodium, and iridium and osmium, a ready test is offered when the point is not to ascertain what the metal is, but merely whether it be present or not. For this purpose we have only to compare the action of the same acid on the alloy and on a piece of steel; the increased action on the alloy immediately indicates the presence of the metal; and by the difference of action, which on experience is found to be produced with the different metals, a judgment may be formed even of the particular one present.

The order in which the different alloys stand with regard to this action is as follows: steel, cromium alloy, silver alloy, gold alloy, nickel alloy, rhodium alloy, iridium and osmium alloy, palladium alloy, platina alloy. With similar acid, the action on the pure steel was scarcely perceptible: the silver alloy gave very little gas, nor was the gold much acted on. All the others gave gas copiously, but the platina alloy in most abundance.

In connection with the analysis of these alloys, there are some very interesting facts to be observed during the action of acids on them, and, perhaps, none of these are more striking than those last referred to. When the alloys are immersed in diluted acid, the peculiar properties which some of them exhibit, not only mark and distinguish them from common steel, and from each other, but also give rise to some considerations on the state of particles of matter of different kinds when in intimate mixture or in combination, which may lead to clearer and more perfect ideas on this subject.

If two pieces, one of steel, and one steel alloyed with platina, be immersed in weak sulphuric acid, the alloy will be immediately acted on with great rapidity and the evolution of much gas, and will shortly be dissolved, while the steel will be scarcely at all affected. In this case, it is hardly possible to compare the strength of the two actions. If the gas be collected from the alloy and from the steel for equal intervals of time, the first portions will surpass the second some hundreds of times.

A very small quantity of platina alloyed with steel confers this property on it: $\frac{1}{500}$ increased the action considerably; with $\frac{1}{200}$ and $\frac{1}{100}$ it was powerful; with 10 per cent of platina it

acted, but not with much power; with 50 per cent. the action was not more than with steel alone; and an alloy of 90 platina with 20 steel was not affected by the acid.

The action of other acids on these alloys is similar to that of sulphuric acid, and is such as would be anticipated: dilute muriatic acid, phosphoric acid, and even oxalic acid, acted on the platina alloy with the liberation of more gas than from zinc; and tartaric acid and acetic acid rapidly dissolved it. In this way chalybeate solutions, containing small portions of protoxide of iron, may be readily obtained.

The cause of the increased action of acids on this and similar alloys, is, as the President of this Society suggested to us, probably electrical. It may be considered as occasioned by the alloying metal existing in such a state in the mass, that its particles form voltaic combinations with the particles of steel, either directly, or by producing a definite alloy, which is diffused through the rest of the steel; in which case the whole mass would be a series of such voltaic combinations; or it may be occasioned by the liberation, on the first action of the acid, of particles which, if not pure platina, contain, as has been shown, a very large proportion of that metal, and which, being in close contact with the rest of the mass, form voltaic combinations with it in a very active state; or, in the third place, it may result from the iron being mechanically divided by the platina, so that its particles are more readily attacked by the acid, analogous to the case of protosulphuret of iron.

Although we have not been able to prove by such experiments, as may be considered strictly decisive, to which of these causes the action is owing, or how much is due to any of them, yet we do not hesitate to consider the second as almost entirely, if not quite, the one that is active. The reasons which induce us to suppose this to be the true cause of the action, rather than any peculiar and previous arrangement of the particles of steel and platina, or than the state of division of the steel, are, that the two metals combine in every proportion we have tried, and do not, in any case, exhibit evidences of a separation between them, like those, for instance, which steel and silver exhibit; that when, instead of an acid, weaker agents are used, the alloy does not seem to act with them as if it was a series of infinitely minute voltaic combinations of steel and platina, but exactly as steel alone would do; that the mass does not render platina wire more negative than steel, as it probably in the third case would do; that it does not rust more rapidly in a damp atmosphere; and that when placed in saline solutions, as muriate of soda, &c. there is no action takes place between them. In such cases it acts just like steel; and no agent that we have as yet tried, has produced voltaic action that was not first able to set a portion of the platina free by dissolving out the iron.

Other interesting phenomena exhibited by the action of acid

on these steels, are the differences produced when they are hard and when soft. Mr. Daniel, in his interesting paper on the mechanical structure of iron, published in the Journal of Science, has remarked, that pieces of hard and soft steel being placed in muriatic acid, the first required five fold the time of the latter to saturate the acid; and that when its surface was examined, it was covered with small cavities like worm-eaten wood, and was compact and not at all striated, and that the latter presented a fibrous and wavy texture.

The properties of the platina alloy have enabled us to observe other differences between hard and soft steel equally striking. When two portions of the platina alloy, one hard and one soft, are put into the same diluted sulphuric acid, and suffered to remain for a few hours, then taken out and examined, the hard piece presents a covering of a metallic black carbonaceous powder, and the surface is generally slightly fibrous, but the soft piece, on examination, is found to be covered with a thick coat of grey metallic plumbaginous matter, soft to the touch, and which may be cut with a knife, and its quantity seven or eight times that of the powder on the hard piece: it does not appear as if it contained any free charcoal, but considerably resembles the plumbaginous powder Mr. Daniel describes as obtained by the action of acid on cast iron.

The same difference is observed if pure steel be used, but it is not so striking; because, being much less rapidly attacked by the acid, it has to remain longer in it, and the powder produced is still further acted on.

The powder procured from the soft steel or alloy in these experiments, when it has not remained long in the acid, exactly resembles finely divided plumbago, and appears to be a carburet of iron, and probably of the alloying metal also. It is not acted on by water, but in the air the iron oxidates and discolours the substance. When it remains long in the acid, or is boiled in it, it is reduced to the same state as the powder from the hard steel or alloy.

When any of these residua are boiled in diluted sulphuric or muriatic acid, protoxide of iron is dissolved, and a black powder remains unalterable by the further action of the acid; it is apparently in greater quantity from the alloys than from pure steel, and when washed, dried, and heated to 300° or 400° in the air, burns like pyrophorus, with much fume; or if lighted, burns like bitumen, and with a bright flame; the residuum is protoxide of iron, and the alloying metal. Hence, during the action of the acid on the steel, a portion of hydrogen enters into combination with part of the metal and the charcoal, and forms an inflammable compound not acted upon by the acid.

Some striking effects are produced by the action of nitric acid on these powders. If that from pure steel be taken, it is entirely dissolved; and such is also the case if the powder be

taken from an alloy, the metal of which is soluble in nitric acid; but if the powder is from an alloy, the metal of which is not soluble in nitric acid, then a black residuum is left not touched by the acid; and which, when washed and carefully dried, is found, when heated, to be deflagrating; and with some of the metals, when carefully prepared, strongly explosive.

The fulminating preparation obtained from the platina alloy, when dissolved in nitromuriatic acid, gave a solution containing much platina, and very little iron. When a little of it was wrapped in foil and heated, it exploded with much force, tearing open the foil, and evolving a faint light. When dropped on the surface of heated mercury, it exploded readily at 400° of Fahrenheit, but with difficulty at 370°. When its temperature was raised slowly, it did not explode, but was decomposed quietly. When detonated in the bottom of a hot glass tube, much water and fume were given off, and the residuum collected was metallic platina with a very little iron and charcoal. We are uncertain how far this preparation resembles the fulminating platina of Mr. Edmund Davy.

In these alloys of steel the differences of specific gravity are not great, and may probably be in part referred to the denser state of the metals from more or less hammering; at the same time it may be observed, that they are nearly in the order of the specific gravities of the respective alloying metals.

The alloys of steel with gold, tin, copper, and chromium, we have not attempted in the large way. In the laboratory, steel and gold were combined in various proportions; none of the results were so promising as the alloys already named, nor did either tin or copper, as far as we could judge, at all improve steel. With titanium we failed, owing to the imperfection of crucibles. In one instance, in which the fused button gave a fine damask surface, we were disposed to attribute the appearance to the presence of titanium; but in this we were mistaken; the fact was, we had unintentionally made wootz. The button, by analysis, gave a little silex and alumine, but not an atom of titanium; menachanite, in a particular state of preparation, was used: this might possibly contain the earths or their basis, or they may have formed a part of the crucible.

M. Berthier, who first made the alloy of steel and chromium,* speaks very favourably of it. We have made only two experiments: 1600 grains of steel, with 16 of pure chrome, were packed into one of the best crucibles, and placed in an excellent blast furnace: the metals were fused, and kept in that state for some time. The fused button proved good and forged well: although hard, it showed no disposition to crack. The surface being brightened, and slightly acted on by dilute sulphuric acid,

* Annales de Chimie, xvii. 55.

exhibited a crystalline appearance; the crystals, being elongated by forging, and the surface again polished, gave, by dilute acid, a very beautiful damask. Again, 1600 grains of steel with 48 of pure chrome were fused: this gave a button considerably harder than the former. This too was as malleable as pure iron, and also gave a very fine damask. Here a phenomenon rather curious was observed: the damask was removed by polishing, and restored by heat without the use of any acid. The damasked surface, now coloured by oxidation, had a very novel appearance: the beauty was heightened by heating the metal in a way to exhibit all the colours caused by oxidation, from pale-straw to blue, or from about 430° to 600° of Fahr. The blade of a sabre, or some such instrument, made from this alloy, and treated in this way, would assuredly be beautiful, whatever its other properties might be; for of the value of the chrome alloy for edge tools we are not prepared to speak, not having made trial of its cutting powers. The sabre blade, thus coloured, would amount to a proof of its being well tempered; the blue back would indicate the temper of a watch spring; while the straw colour towards the edge would announce the requisite degree of hardness. It is confessed, that the operation of tempering any blade of considerable length in this way, would be attended with some difficulty.

In the account now given of the different alloys, only one triple compound is noticed; namely, steel, iridium, and osmium; but this part of the subject certainly merits further investigation, offering a wide and interesting field of research. Some attempts to form other combinations of this description proved encouraging, but we were prevented, at the time, by various other avocations, from bestowing on them that attention and labour they seemed so well to deserve.*

It is a curious fact, that when pure iron is substituted for steel, the alloys so formed are much less subject to oxidation. Three per cent. of iridium and osmium fused with some pure iron, gave a button, which, when forged and polished, was exposed, with many other pieces of iron, steel, and alloys, to a moist atmosphere: it was the last of all showing any rust. The colour of this compound was distinctly blue; it had the property of becoming harder when heated to redness and quenched in a cold fluid. On observing this steel-like character, we suspected the presence of carbon; none, however, was found, although carefully looked for. It is not improbable that there may be other bodies, besides charcoal, capable of giving to iron the properties of steel; and though we cannot agree with M. Boussingault,† when he would replace carbon in steel by silica or its

* It is our intention to continue these experiments at every opportunity, but they are laborious, and require much time and patience.

† Annales de Chimie, xvi. 1.

base, we think his experiments very interesting on this point, which is worthy further examination.

We are not informed as to what extent these alloys, or any of them, have been made at home, or to what uses they have been applied; their more general introduction in the manufacture of cutlery would assuredly add to the value, and consequently to the extension of that branch of trade. There are various other important uses to which the alloys of steel may advantageously be applied. If our information be correct, the alloy of silver, as well as that of platina, has been, to some considerable extent, in use at His Majesty's Mint. We do know, that several of the alloys have been diligently and successfully made on the Continent; very good specimens of some of them having been handed to us; and we are proud of these testimonies of the utility of our endeavours.

To succeed in making and extending the application of these new compounds, a considerable degree of faithful and diligent attention will be required on the part of the operators. The purity of the metals intended to form the compound is essential; the perfect and complete fusion of both, must in every case, be ascertained: it is further requisite, that the metals be kept for some considerable time in the state of thin fusion; after casting, the forging is with equal care to be attended to; the metal must on no account be overheated; and this is more particularly to be attended to when the alloying metal is fusible at a low temperature, as silver. The same care is to be observed in hardening: the article is to be brought to a cherry-red colour, and then instantly quenched in the cold fluid.

In tempering, which is best performed in a metallic bath properly constructed, the bath will require to be heated for the respective alloys, from about 70° to 100° of Fahrenheit above the point of temperature required for the best cast steel. We would further recommend, that this act of tempering be performed twice; that is, at the usual time before grinding, and again just before the last polish is given to the blade. This second tempering may, perhaps, appear superfluous; but upon trial its utility will be readily admitted. We were led to adopt the practice by analogy, when considering the process of making and tempering watch springs.

Article XI.

Memoir illustrative of a general Geological Map of the principal Mountain Chains of Europe. By the Rev. W. D. Conybeare, FRS. &c.

(*Continued from* p. 149.)

Great Saliferous Series,

Including, *a.* The rothetodteliegende.
b. The alpine or magnesian limestone.
c. The variegated or new red sandstone.

In comparing the series of deposits which immediately succeed the great carboniferous order as presented in England, and in some parts of the Continent, we shall, perhaps, perceive rather a parallelism than identity of formations in the representatives of rothetodteliegende and the alpine limestone; but in the variegated sandstone an unequivocal identity is manifested.

a. Rothetodteliegende.—Conglomerates, including rolled fragments of the neighbouring rocks, characterise this formation: the cement is sometimes argillaceous, sometimes quartzose; by the diminution in size of the fragments, the rock often passes into a sandstone more or less granular. Beds of red micaceous shale alternate in the formation; it contains subordinately in some places carboniferous beds (distinct, however, according to Freisleben, from those of the true coal formation). Trap rocks (amygdaloid and porphyry) are often associated with these deposits, usually, as it should appear, in their lowest members where they rest on the true coal series. Beds of limestone also occur, though sparingly. The upper members where they support the alpine limestone, pass into a calcareous conglomerate called in the Hartz and neighbouring districts, the Weissliegende. This is by some authors considered as a distinct formation; by others (with whom I am inclined to agree), it is included as the last deposit of the rotheliegende.

Ores of iron, cobalt, and copper occasionally occur.

The petrifactions of this rock appear to belong chiefly, if not exclusively, to the vegetable kingdom.

All circumstances indicate a near connection, but not an identity, of formation between the rothetodte and the great carboniferous series.* It seems rather to hold an intermediate place

* I have to add to the authorities I have previously adduced in confutation of the arrangement which would identify the rothetodte and the old red sandstone of Britain, that of Dr. Boué, particularly important, because he has minutely examined the old red sandstone of Scotland, which, it has been contended (and principally on the ground of his description), presented the closest analogies to the rothetodte, and is equally acquainted with all the foreign localities of the latter rock, from recent journies. I have now a series of letters of the highest interest from this author to Prof. Daubeny before me, in which he states, that "he agrees with Prof. Buckland in dis-

between this and the following deposits, and to introduce, as it were, the latter.

b. The Alpine Limestone; Zechstein, or Magnesian Limestone. (*Werner's first Floetz Limestone.*)—This formation is very variable in different places, and may be said generally to present in distant districts a parallelism rather than identity of deposits. The prevailing rock in the continental deposits (zechstein) is a grey compact, and generally argillaceous limestone; sometimes slightly granular, and having a small degree of lustre from the facettes of the calcareous crystals imbedded: its colour is grey or bluish, sometimes acquiring a reddish tinge; it contains subordinate beds of magnesian limestone, of ferriferous limestone, of cellular and crystalline limestone (rauchwacke), of fetid limestone, and of bituminous and cupriferous marl slate. Copper, galena, calamine, and mercury, are among the metallic products of this formation; and the association of rock salt and gypsum attest its connexion with the superimposed sandstones which also abound in these minerals.

Organic remains are scarce in this formation, speaking generally, but yet in particular spots and beds occur even abundantly: the following species are enumerated by Sclottheim; but I am not at present able to identify all the names employed with the synonymes in English writers.

Gryphites aculeatus,
G. gigas,
G. arcuatus,
Pecten textorius,
Pecten salinarius,
Mytilus rostratus,
Terebratula alata,
Terebratula lacunosa,

tinguishing the rothetodte from the old red sandstone." I hope hereafter to communicate from these letters a sketch of the recent discoveries of this active and persevering geologist; and here then for the present, at least, I shall close this controversy. I had originally intended to have given more minute extracts from the original works referred to; but unless the accuracy of the general statements above given shall be questioned, it will, perhaps, be superfluous to do so; if they should be controverted, I am then prepared to support them. En resumè against the proposed identification of the rothetodteliegende and our oldest sandstone. I have the express testimony of Buckland, Humboldt, Boué, Daubuisson, and Beudant, and (as I contend) the implied evidence of every other writer on the subject, excepting, perhaps, of Prof. Jamieson. Whether it be more properly referable to the upper part of the carboniferous, or the lower part of the saliferous series, is a distinct question, on which much division of opinion exists, and which is after all not very material. I have endeavoured to compromise matters by treating it as an intermediate link between them.

I have thus endeavoured to support, as I may, the opinions which to me appear most probable against an adversary from whom, however, I can never dissent without hesitation. Mr. Weaver's memoir on the South-east of Ireland will long remain as one of the most perfect models of geological description, and must excite our regret that we have not been favoured with more original communications from the same pen; while his extracts from the writings of continental geologists, published in the *Annals*, equally attest his power of generalising, and presenting under their most luminous point of view, the observations of others.

Terebratula trigonella,
Ammonites ammonius,
Ammonites amaltheus,
Ammonites hircinus,
Nautilus coactus,
Orthoceratitæ,
Joints of encrinites and pentacrinites,
A species of trilobite.

Bones of monitors and of fish, a separate line belonging to the vegetable kingdom, leaves of dicotyledonous plants (in which respect there is a distinction between these remains and those of the coal fields which are all monocotyledonous), and fragments related to the lycopodium and bamboo, but no true ferns.

c. The Variegated or new Red Sandstone exhibits a series of friable sandstones and argillaceous marls, in which a red colour varied by streaks and spots of a greenish-yellow, &c. prevails. The sandstone predominates in the lower members, and is associated with conglomerate beds. Gypsum and rock salt occur in this deposit as in that of the zechstein. Iron is the only metal, I believe, which it has yet yielded.

Distribution.—It is easy to trace generally the distribution of the whole series, but much obscurity still hangs over the exact demarcation of its individual members. This it may now be expected will shortly be dissipated in as far as it arises from our hitherto imperfect knowledge of the structure of the countries in which it occurs, by the publication of the works alluded to in the beginning of these essays; but in part it results from a physical cause which cannot so readily be surmounted; namely, the difficulty, if not impossibility, of ascertaining in localities where the middle series of limestones (*b*) may happen to be wanting; whether the sandstones and conglomerates belong to the upper class (*c*), or the lower (*a*): following the same route which has been traced in the preceding articles, we have first to examine,

(A.) *The Coasts of the Baltic.*

The red marl containing gypsum, which occupies a very extensive tract in the centre of Russia, appears to skirt the transition district of Esthonia, near Riga. Its continuation ought to be sought for between the transition and more recent districts in Scania and the Danish isles; but these districts have not yet been described with sufficient precision to enable us to speak of them with certainty.

(B.) *The British Isles.*

1. It is possible that the sandstones of the Orkneys may either wholly, or in part, belong to this series.

2. The same observation will apply to those of the Sutherland coast on the north-east of Scotland.

3. In the Hebrides, that portion of the sandstone which is closely associated with the gryphite limestone is probably referable to this series.

4. It is generally believed that the sandstones of the lowlands are partly to be ascribed to the old red sandstone; viz. where they skirt the Grampian chain, and partly to the coal sandstones, the present series not occurring in that tract.

5. On the south of the southern or transition chain of Scotland, however, the sandstones of the present series certainly occur in the valley of the Tweed, and in the shores of the Firth of Solway, in Dumfriesshire, being in the latter district connected with the mass of the same formations stretching into the north of Cumberland.

6. In Ireland, the saliferous sandstones underlie the basalt of the Ulster district, but are confined to a narrow zone encompassing that area.

7. In England, the saliferous sandstone mantling round the south and south-west of the penine chain (see the account of the coal districts) occupies the central counties, sending a branch north-west to the point where the cumbrian chains inosculate with the former, and in the opposite direction, forming a band between the lias and the coal and transition series, through Warwickshire, Worcestershire, and Gloucestershire. In South Gloucester, Somerset, and the south of Monmouth and Glamorgan, these formations have a very irregular outline, since they form upfillings through which the elder rocks of the coal series protrude in all the loftier ranges; in Devonshire they are similarly disposed among the transition chains.

In all these places the lowest members appear to abound in conglomerates; those of Devonshire, which are associated with amygdaloid, have every feature of the German rothetodte, but the magnesian limestone is here wanting, and the variegated sandstone lies immediately on those conglomerates.

I have, in the preceding number, suggested the inquiry, whether the rock distinguished in Smith's Yorkshire as the Pontefract rock may not possess similar analogies.

The magnesian limestone forms a continuous band from the south of Durham through Yorkshire and Nottinghamshire.

Mr. Smith, in his geological map of Yorkshire, subdivides the magnesian limestone, or, as he calls it, red-land limestone, thus:

1. A hard bluish-white thin bedded stone which at Kinnersley, Knottingly, and Brotherston, makes the lime celebrated for agricultural purposes.

2. Red and blue clay and gypsum.

3. A soft yellowish calcareous freestone or magnesian limestone.

These beds are separated from the superior red marl by a thick conglomerate.

Mr. Buckland has observed in Yorkshire, beds closely resem-

bling the rauchwacke or cellular limestone of the Continent, associated with magnesian limestone.

In the southern counties, these formations are represented by a calcareo-magnesian conglomerate, occasionally, but very rarely, passing into limestone beds of uniform texture. These conglomerates bear a great analogy, as Mr. Weaver has well remarked to the weissliegende of Germany.

These formations must be considered as parallel to, rather than identical with, the alpine limestones of the Continent.

The above deposits are comparatively very limited in England, and nine-tenths of the tract occupied by the great series we are now describing, is exclusively possessed by the superincumbent variegated sandstone and marl.

Salt or salt springs occur in Cheshire, Staffordshire, and Worcestershire; gypsum, passim, and sulphate of strontian, in Gloucester and Somersetshire.

(C.) *Western France.*

The new red sandstone which crosses the channel from Devonshire, is seen, though not extensively, skirting the transition rocks of Brittany; but the lias and oolite advance so near to them, as almost to overlie and conceal it; as also seems to be the case in the centre of that country, against the northern edge of that great group of primitive ridges branching off from the Cevennes; but we want information on this district.

According to the interesting communications of Dr. Boué, the variegated sandstone exists in patches (par lambeaux) in the south-west of France. It is there represented by marls with compact and fibrous gypsum (Cognar St. Froult, near Rochefort), and sometimes immediately covered by Jura limestone, &c. At the foot of the Pyrenees between St. Giron and Rimont, it is more extensively developed.

(D.) *Spain.*

Humboldt is of opinion that the limestone of Montperdur is that belonging to the present series. The specimens I have seen, and the fossils described as occurring in it, would certainly induce me to assign it to a later era (namely, that corresponding to our green sand), since it much resembles those rocks in the exterior chains of the Alps which are, by Messrs. Buckland and Brogniart, referred to that class; but I can hardly bring myself on such slight data even to suggest an inquiry militating against so high an authority. Be this as it may, after crossing the Pyrenees, the rock salt of this formation occurs associated as usual with gypsum at Cardona (a description of which will be found in the fourth volume of the Geological Transactions). The celebrated conglomerate mountain of Montserrat in the same quarter, is, perhaps, referable to the same era; and we find gypsum and rock salt abundantly distributed along the course of

the Ebro from below Saragossa to above Tudela. It is difficult to speak of a country whose geology has yet never received a strictly scientific examination; but enough is known to teach us that the central and western districts are principally occupied by primitive chains, while the east and south-east (with the exception of the transition chain of the Sierra Nevada) exhibit little but calcareous mountains, among which gypsum is plentifully interspersed. As we shall hereafter see that the limestone formation, answering in age to our magnesian limestone, swells into great importance on the Continent, and constitutes large mountain zones encircling the Alps, &c. which are in like manner characterised by the intermixture of gypsum, it is no improbable conjecture that these deposits belong to the same period.

(E.) *The Alps.*

We find these formations forming a zone on either side of the Alps; on the north, interposed between the older rocks and great Nagelflue of Switzerland, which was once itself considered as belonging to them, but has been proved by subsequent researches to be of much more recent date, and contemporaneous with the sandstones of the basin of Paris. The red sandstone is here intimately associated with alpine limestone, which corresponds with the calcareous formations already described as coeval with our magnesian limestone; and gypsum and salt may be found interspersed through the whole series. A similar character applies to the zone on the south side of the Alps; here the red sandstone may be seen to the greatest advantage in the valley of the Adige, ten miles north of Trent, and in the valley of Avisio, which descends from the Val di Tassa into that of the Adige. In the same neighbourhood a porphyry occurs associated with these formations on the south of the Alps only.

The reader is referred for further particulars to the excellent memoir of Prof. Buckland, *Annals of Philosophy*, June, 1821.

It is probably the limestone of this formation belonging to the southern alpine zone, which extends into Carinthia, Istria, Dalmatia, &c.; the limestone of the Apennines, and much of that in Greece, may also, perhaps, be referred to the same era.

It is not to be understood that all the limestone chains bordering the Alps belong to the present series. Parts on the exterior are undoubtedly referable to the oolitic series; and others, as it should appear, parallel to the limestones associated with our green sand. The great disturbances which have affected these colossal chains, and the almost inaccessible nature of much of the ground, must long leave considerable obscurity on the exact demarcation of their constituent formations.

(F.) *Districts North of the Jura and on the Banks of the Rhine.*

The strata of the Jura chain cropping out to the north exhibit

beneath the lias along their northern and north-western escarpment the saliferous sandstone (Lons le saulnier, &c.).

Dr. Boué has traced the variegated sandstone, alpine limestone, and rotheliegende, skirting the Vosges on the left bank of the Rhine, where the continuation of this tract approaches the slate mountains of the Ardennes. It has been described by Omalius d'Halloy, who classes this series agreeably to its disposition in England as the oldest of the horizontal rocks, contrasting it with the inclined position of the coal and older formations.

Keferstein states, that the primitive range of the Schwartzwald and Odenwald on the right bank of the Rhine is succeeded on the east, first by rothetodte, then by alpine limestone, and thirdly by variegated sandstone; and according to his representation, the Wurtzburg calcareous platform is a portion of this band of alpine limestone. Boué and Humboldt, however, I believe, consider the same tract as muschel kalkstein. Having hastily traversed it myself, I felt also inclined to embrace the latter opinion.

Between this limestone and the cavernous (Jura) limestone of Bamberg, a tract of conglomerate and sandstone intervenes. Keferstein refers this to the variegated sandstone forming the third zone, consistently with his general ideas of the structure of this district; but if the Wurtzburg tract be muschel kalk, this sandstone district is, perhaps, equivalent with the sand of our inferior oolite. I felt much embarrassed by this district when I traversed it, and have not yet been able to procure information which fully satisfies me.*

After passing the platform of Jura limestone between Bamberg and Bayreuth, however, the red marl of the variegated sandstone is unequivocally displayed resting against the Bohemian chains, the Fichtelgebirge, and the Thuringerwald.

(G.) *North of Germany.*

In the point to which we have now arrived, we may observe skirting the Thuringerwald all the formations noticed at the head of this article, viz. the red marl and gypsum; the calcareous beds associated with the cupriferous marl slate, and at the bottom the rothetodte: a shell limestone answering to our lias rests on these beds, and separates this from a similar district encircling the detached ancient group of the Hartz mountains: here, and in the continuation of this district towards Halle, the rothetodte is to be observed in many places in contact with the coal formation, and always above it. Rock salt is found in numerous points in this quarter, along the line between Osnaburg and

* I have, therefore, followed the authority of Keferstein in colouring my map, preferring to copy the errors, if errors they be, of the best published document, rather than substitute an original representation from very imperfect observations, which would, therefore, have been quite as likely to prove erroneous.

Magdeburg throughout the south of Hanover. (See the works of Freisleben.)

The zone of these rocks surrounding the Thuringerwald continues to skirt the prolongation of the same great mountain band through Saxony, where it assumes the name of the erzegebirge, through Silesia, where it changes its appellation for that of the riesengebirge. It occurs on both sides this chain, extending on the south into the great basin of Bohemia, and covering the coal formation of that country and the adjoining parts of Silesia. This district has been fully described by Von Raumer,* and in part also by Von Buch in his account of Glatz.

(H.) *Hungary.*

These formations appear to skirt in like manner both sides of the Carpathian chain, which is still only a continuation of this same great primitive band traversing central Europe. The most extensive salt mines which have ever been worked are to be found in the northern sandstone zone at Wielictzka† on the south of Cracow, and salt is also worked along the inner zone in several valleys descending to the west from the chain where it trends round Transylvania. The primitive ridge of the Carpathians, turning eastwards on the south of the Danube near its mouth, assumes the name of Mount Balkan, and proceeds to the coast of the Euxine, which cuts it off; but the transition rocks on the south of the peninsula of the Crimea, appear to form a portion of its northern exterior chain, and the Caucasus to form its prolongation; both these ranges are skirted by conglomerates, probably of this formation.

(I.) *Russia.*

The sand of this formation, containing gypsum, appears to be very abundant in the north and east of European Russia. Mr. Strangways has recently laid much important information on the mineralogical relations of this vast empire before the Geological Society, in which all the particulars hitherto collected are given. It will here suffice to observe, that if a line be drawn from Riga north of Moscow to the banks of the river Oural, this formation will be found plentifully distributed on the north and east of it, especially along the Volga and its branches on the north-east of Moscow: it appears indeed to extend to, and

* Mr. Fichtel says, that on the north this zone extends from Wielictzka into Moldavia, in which interval he enumerates 58 places where salt is worked or salt springs found, and on the south from Eperics, 400 or 500 miles eastwards through Transylvania, affording 159 localities of salt.

† M. Beudant fancies the salt of the Wielictzka mines to be derived by infiltration from a superior sandstone which he assigns to the tertiary æra, because it contains lignites. This hypothesis is highly improbable; lignites are by no means confined to the tertiary deposits. Mr. Buckland, who has visited the spot, felt convinced that the salt mines were in genuine red marl, and, I believe, observed, in the same vicinity, green sand overlying that formation. This is probably the lignite sandstone of M. Beudant.

invest the Oural mountains with, the intermixture of a cupriferous sand, probably allied to the cupriferous beds associated in this formation in Germany and the Tyrol, &c.

On the south of the Oural chain, it appears to stretch to the Caspian, and to spread very extensively in the adjoining regions of Asia.

(*To be continued.*)

Article XII.

Observations on the Advantages of Oil Gas Establishments. By M. Ricardo, Esq.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Brighton, Feb.* 12, 1823.

It is now nearly two years since I first addressed you on the subject of oil gas, when you did me the favour to insert in the *Annals of Philosophy* a paper "On the Comparative Advantages of Oil and Coal Gas." These observations were founded upon a few experiments I was enabled myself to try on the small scale, the reports of those who possessed an oil gas apparatus, and upon what I conceived would be the results obtained at an oil gas establishment on an extensive plan. Since that period I have had ample opportunities afforded me of making a trial upon a larger scale at the Whitechapel-road Gas Works, situated in Oldford, and the result has been a full and satisfactory confirmation of what I had before advanced. The formation of a Company for carrying this work into effect was in contemplation at the time I first wrote. A capital was raised, an Act of Parliament was obtained, and to Messrs. Taylor and Martineau devolved the task of erecting the works, which were executed in a manner highly creditable to these gentlemen. About two or three weeks before Christmas, 1821, the public were supplied with gas, only five months having been occupied in executing the work and laying the mains. The first annual meeting took place on Thursday, the 6th of February last, when a most satisfactory report was presented by the Committee, and a dividend of two and a half per cent. declared on the capital advanced; not a dividend made for the occasion, but one arising from a clear profit over and above the expenditure, of which every proprietor had an opportunity of satisfying himself by a reference to the accounts which were laid before the meeting. This certainly may be considered as a strong proof in favour of oil gas, when it is known that the mains of this establishment run through, a district in which there is as little demand for

light as any in the vicinity of London. This Company originated with some few gentlemen in the neighbourhood who were anxious to have the road lighted with it. Many who subscribed did it without any view to profit, wishing only for the advantages of the light. Messrs. Taylor and Martineau held out no very flattering prospects, although they contemplated that it might not be unattended with profit; and such too was the opinion which I had formed when I assisted in promoting it.

Of the 10,000*l.* the capital subscribed for, only 8000*l.* have been advanced. Two sets of retorts, with the necessary apparatus, a gasometer containing 8000 cubic feet, and capacious reservoirs for oil, have been constructed; seven miles of main have been laid in various directions, the total cost having been about 7,300*l.** There are at present only 100 customers supplied from this establishment, but it is difficult to say, how many lights are in use, as the gas is supplied by meters, and paid for according to the quantity consumed; so that any person may have as many burners as he pleases. The average number in constant use may be reckoned at about 500 or 600; besides which there are about 180 public lights supplied at a price which yields no profit. One man as gas-maker, and a boy to assist him, are the only labourers required, and without any addition, these might supply double the number of lights. In this case, the current expences of labour, wear and tear, rent, and incidentals, would continue the same, the only additional charge being the cost of oil and coals. In my former statement, when I calculated the expences at 5*s.* 6*d.* per 1000 feet as a fixed sum, I was incorrect. This sum must be constantly diminishing with the increased demand for gas. On the present scale at this gas work, the expences may be estimated at 6*s.* per 1000 feet; if the consumption was doubled, it would be only 3*s.* per 1000 feet; and if the apparatus supplied to the full extent of what our capital would allow us, it would be considerably less; for with the addition of another gasometer and one labourer, during the winter months, I have no doubt from the observations I have made, that between 3000 or 4000 burners might be kept supplied. Two pairs of retorts working 8 or 10 hours a day, are found sufficient to provide all the gas for the present winter consumption, amounting to about 6000 feet per night. If the whole six pairs were at work, and kept employed night and day as they are in coal gas works, more than six times that quantity might be produced. If the Company had erected their own buildings, and furnished themselves with another gasometer, their capital subscribed would have been sufficient to have covered all these

* The sum expended, as shown by the accounts, is about 7,700*l.* but of this nearly 400*l.* are for gas meters, and 760*l.* for an Act of Parliament. It should be observed that the building has been erected by the ground landlord, who receives an adequate rent.

expences. At the Brighton Coal Gas Works upwards of 30,000*l.* have been expended; and, I believe, without a material increase to their works, they would find it difficult to supply gas for 3000 lights.

The report from the gas-maker of the quantity of gas produced from a given quantity of oil, is equally satisfactory. This depends in a great degree on the nature of an oil; for an equal quantity of gas cannot be procured from the very inferior sorts as from those of a better quality. Whale oil is found to be the best for the purpose; cod oil somewhat inferior; yet from eight tons of the latter containing 2016 gallons, 201500 cubic feet of gas were obtained, which is within a trifle of 100 feet per gallon. This is a large production from that description of oil; but I see no reason, why, with good management, the same quantity should not always be produced; much certainly depends upon this, but it is soon acquired by practice and observation. The regulation of the heat of the retorts, and supplying them properly with oil, is of the greatest importance in gas making. The Oldford establishment has been fortunate in obtaining an operator who has equalled their most sanguine expectations. There are inferior oils which it may be the interest of a Company to purchase from lowness of price; these of course are not expected to produce so much gas; and lowness of price is not always a recommendation, as there are other circumstances besides variation of product which render some oils less eligible than others. It has been observed that the advocates for oil gas do not make any allowance for waste arising from leakage of pipes, &c. This, at the Oldford Works, is very small indeed. The valve leading from the mains has been opened during the day, and kept so for some time with the smallest perceptible fall in the gasometer. This loss in the coal gas works, if what is stated be correct, is so great that it is difficult to account for it, and it would seem almost impossible it should arise from escape only. It is well known that coal gas injures the pipes it passes through; which, in no degree, occurs with oil gas: may not this fact account for the difference of loss?

The foregoing statements, I think, clearly prove the advantages which an oil gas concern is likely to yield in point of profit to those who embark in such an undertaking. To the consumer of gas, the advantages are equally palpable. An individual in the vicinity of the Works, has his premises lighted up with oil gas, and the following is the result of one year's observation; it is somewhat more than a year, but I will not consider the extra time. He has in his shop five large argand burners burning from sun-set till nine o'clock, and on Saturdays till eleven o'clock. In his counting-house, he has two burners, and in his warehouse one; these last are not constantly lighted, and he estimates them at one and a half, so that the number of lights

may be considered as six and a half, the average number of hours of burning per night is about three hours. I estimated this before at two and a half; it was said to be three and a half: I have taken the medium; this, allowing the extra time on Saturday, would be 20 hours per week, or 1,040 per year. The annual consumption will be about 8,800 cubic feet, for which at 50*s.* per 1000 feet, deducting five per cent. will be about 21*l.* besides the hire of the gas meter; each burner will consume about 1,350 cubic feet per year, which very little exceeds one and a quarter foot per hour. The light of these burners is fully equal to, if not exceeding, that of coal gas consuming five feet per hour, thus realising upon a large scale all my experiments, which have tended to prove that one foot of oil gas is equal to four feet of coal gas. The illuminating power of these two burners has been tried by a gentleman whose accuracy in experiments of this kind may be relied on, and whose interest is as great in the success of coal gas as of oil gas: his trials have all been followed by the same results. The cost too will be equally favourable for oil gas. The use of the gas meter gives an advantage over the ordinary mode of charging per light, as in the latter case the consumer must pay for a stated number whether he uses them the whole time or not; but supposing he should pay for six and a half burners, the charge would be 26*l.* and if this were estimated, according to the quantity consumed at 15*s.* per 1000 feet, and considering one cubic foot of oil gas as only equal to three and a half cubic feet of coal gas, as I originally stated it, the cost then would be 23*l.* 8*s.* making a difference considerably in favour of the former, and likewise showing the decided advantage of the gas meter. The above statement will, I think, be conclusive to any but the most prejudiced, of the superiority of oil gas over coal gas in an economical point of view.

Of the benefits arising from its introduction into private houses, no one can speak more satisfactorily than myself, nor can any one more seriously regret the necessity I have been under of relinquishing the comfort and luxury arising from it in consequence of my retirement here on account of my health. The whole of my house was lighted with it; and all the advantages, great as they were, which I anticipated from it, were infinitely more than realised. There was not a single annoyance, or the slightest inconvenience arising from the use of it; while the brilliancy of the light, the cleanliness, the saving of trouble, and many other comforts attending it, were a constant theme of admiration, and now as constant a source of regret. Could the benefits of this mode of lighting be generally known, and felt, and duly appreciated, I have no doubt that oil gas companies would be universally established, and every house lighted with it. It is difficult to say what the economy of this mode of lighting is, that must depend upon the quantity of light; it is, however, satisfactory to know, that there is no waste; you may

be as profuse or as economical as you please, and you may have double or treble the light at the same cost as tallow candles; four or five times as much if compared with sperm oil, and above twelve times as much if the comparison be made with wax candles.

I know not that any thing can be more satisfactory in favour of any new improvement than a successful issue of a fair and impartial trial; and the results which I have now stated, of a year's trial at the Oldford Works, may be equally applicable to any other establishment of a similar description. It can hardly be erected on more disadvantageous ground; and if similar success should not ensue, it cannot arise from the planning and execution of the work, but from some other cause wholly unconnected with the nature of the establishment, either from want of consumption, or from improper management, and to which any other concern is equally liable. The great question in the formation of a gas company is, Which is most eligible, coal or oil? Which is likely to absorb the least capital? Which is likely to promise the fairest return? Which is likely to be attended with least loss in case of failure? Which is likely to afford the greatest satisfaction to consumers in general? To these queries, I do not hesitate for one single moment answering *oil gas*. There is not a single point in which it has not the most decided advantage; and it is only because these advantages are not generally known, or that they are disallowed owing to the gross misstatements of those interested, that oil gas is not universally adopted. All means are resorted to to cry down oil gas; and I understand that in some of the provincial papers a warm contest has been kept up, and that the opinions of scientific men have been brought forward to prove the incorrectness of the statements concerning the comparative illuminating powers of the two gases. It would be difficult to account for the discrepancy of opinion which exists on this subject (some estimating it as one to two; others as one to two and a half; some again as one to three), if we did not know that the goodness of oil gas depends upon the construction of the apparatus, and the mode of using it, and that oil gas of all the qualities just mentioned may be produced. The gas upon which I have experimented, and upon which the observations I have before made were founded, was produced from works upon a large scale, erected by Messrs. Taylor and Martineau; and the peculiar excellence of their arrangement is, that the gas produced from the action of their apparatus and retorts is always of a superior quality, which was most satisfactorily proved by Dr. Henry, in his paper read before the Royal Society. It is needless for me here to enter into a detail of experiments which I was trying, and which, for the reasons I have before given, I was reluctantly obliged to give up. I may, perhaps, take some future opportunity of entering more fully into that subject; for

the present, I need only say, that the quantity of light may be augmented or diminished by different modifications of burners, by lessening or increasing the pressure of gas, at the same time enlarging or diminishing the external hole through which it passes. Indeed in measuring the proportions of light produced from oil and coal gas, there are so many circumstances to be considered, that no two experimentalists would be satisfied with the results obtained by others. The most satisfactory proof which can be brought forward is the practical result of observations made by a disinterested and intelligent consumer, and which is shown by a computation of pounds, shillings, and pence, more intelligible to those usually interested in gas concerns than all the philosophical or chemical experiments that can be tried.

I hope, from what I have above stated, it will not be supposed that I mean to underrate the advantages of science; you, Sir, I am sure, know me well enough, and have been sufficiently acquainted with my pursuits, to exonerate me from such a charge; but the present question is not so much one of science as it is of economy and utility; and in such a question, practical experience would certainly take the lead of scientific experiments. We all know the results of the inquiry on the famous oil question, which will not readily be forgotten. It must have had the effect of teaching the public, that in similar points of dispute, they must look to other authorities than the mere dicta of scientific men; and no authority can be more satisfactory than that which results from the agreement of scientific experiments with practical results.

I would have transmitted to you a copy of the report of the Oldford Oil Gas Company, but it is not yet printed: it details the progress of the concern, and expresses the satisfaction of the Committee with the favourable account which they are enabled to lay before the Proprietors, and bears testimony of the correctness of all the statements which were made by Messrs. Taylor and Martineau at the commencement, in all of which they have been fully borne out after a fair and satisfactory trial. I am, yours, &c. M. Ricardo.

Article XIII.

Abstract of a Memoir entitled "An Attempt to ascertain the Chemical Composition of those Minerals which possess the same Crystalline Form as Pyroxene." By H. Rose.*

The author of this paper observes, that there are many minerals which, from whatever place obtained, always possess the

* From Schweigger's Journal, vol. v. New Series.

same form and constituent parts. Of this agreement he adduces feldspar and emerald as examples; but there are other minerals, as pyroxene, amphibole, garnet, and mica, which, possessing similar forms, wherever they occur, differ greatly in their composition. This last mentioned circumstance has occasioned great difficulty in arranging minerals according to their composition.

It is observed, that M. Mitscherlich has removed much of this difficulty by showing that certain bodies, when containing the same number of atoms, may exchange their places in compounds without inducing any alteration of crystalline form; according to M. Mitscherlich, most oxides which contain two atoms of oxygen are isomorphous; and although his experiments were made with artificial salts, it is presumed that the same obtains with respect to crystalline minerals.

To illustrate this position, M. Rose has observed that the analyses of different specimens of pyroxene show, that all minerals which have the crystalline form of pyroxene are bisilicates of the four isomorphous bases, lime, magnesia, protoxide of iron, and protoxide of manganese; in all these, the oxygen of the base is to that of the silica as 1 to 2. If the reasoning of M. Mitscherlich be applied to the analysis of various substances classed by Haüy with pyroxene, it will be observed that they agree in composition with that substance; viz. augit, malacolite, sahlite, baikalite, coccolite, alakit, mussite, diopside, and fassaite.

The following analyses were made by M. Rose in Prof. Berzelius's laboratory at Stockholm, and most of them were several times repeated; the minerals which possess the crystalline form of pyroxene are classed by M. Rose under the following heads:

1. Pyroxenes with lime and magnesia as bases.
2. Pyroxenes with lime and protoxide of iron as bases.
3. Pyroxenes with lime, magnesia, and protoxide of iron, as well as some protoxide of manganese as base.
4. Pyroxenes with lime and protoxide of manganese as bases.

1. *Pyroxenes with Lime and Magnesia as Bases.*

These pyroxenes are mostly white, and form the colourless and usually transparent malacolites, which are sometimes, by slight admixtures, yellowish and greenish. The proportion of lime and magnesia is in almost all which have been analysed very constant, both having the same quantity of oxygen, and together half as much as the silica.

White Malacolite from Orrijervi, in Finland.

Is white, only greyish when mixed with galena; occurs in large crystalline masses with distinct cleavage; semihard, and very translucent at the edges. Mr. Rose's analysis gives

Silica	54·64	containing oxygen	27·48
Lime	24·94		7·0
Magnesia	18·0		6·97
Oxide of manganese	2·0		
Oxide of iron with magnesia	1·08		
	100·66		

Yellow Malacolite from Longbanshyttan, in Wermeland.

It occurs with red silicate of manganese in magnetical iron ore. Its colour is yellowish; its powder of a lighter colour; it is semihard; gives with difficulty sparks with steel; is translucent at the edges. M. Rose's analysis gave

Silica	55·32	containing oxygen	27·82
Magnesia	16·99		6·58
Lime	23·01		6·46
Oxide of manganese	1·59		
Oxide of iron	2·16		
	99·07		

M. Hissinger has analysed another malacolite from Longbanshyttan; the composition is nearly the same.

Silica	54·18	containing oxygen	27·25
Magnesia	17·81		6·89
Lime	22 72		6·38
Oxide of manganese	2·18		
Oxide of iron	1·45		
Loss by heating	1·20		
	99·54		

M. Bonsdorf, of Abo, has analysed a white malacolite from Tammare, in Finland, which gave the following results:

Silica	54·83	containing oxygen	27·58
Lime	24·76		6·95
Magnesia	18·55		7·18
Alumina	0·28		
Oxide of iron	0·99		
Loss by heating	0·32		
	99·73		

The Count of Trolle Wachtmeister analysed a white malacolite from Tafel Tyotten, in Norway; its composition was,

Silica	57·40	containing oxygen	28·87
Lime	23·10		6·48
Magnesia	16·74		6·48
Alumina	0·43		
Protoxide of iron	0·20		
	97·87		

Pyroxene from Pargas gave Mr. N. Nordenskiold the following composition:

Silica	55·40	containing oxygen	27·7
Lime	15·70		4·4
Magnesia	22·57		9·3
Oxide of manganese	0·43		
Alumina	2·83		
Oxide of iron	2·50		
	99·43		

2. *Pyroxenes with Lime and Protoxide of Iron as Bases.*

Hedenbergit from Tunaberg, in Sadermanland.*

The colour is greenish-black; it is semihard in a high degree. It occurs among the masses thrown out from a mine which is now deserted (Marmorsgufvan) not far from the cobalt mines at Tunaberg, together with quartz, partly pure and large foliated; partly granular with magnetical iron ore. M. Rose's analysis gave the following result:

Silica	49·01	containing oxygen	24·65
Lime	20·87		5·86
Protoxide of iron	26·08		5·93
Magnesia and oxide of manganese	2·98		
	98·94		

3. *Pyroxenes with Lime, Magnesia, and Protoxide of Iron, as Bases, together with more or less Protoxide of Manganese.*

In these varieties of the pyroxene, a constant proportion of the bases is wanting; and there is, therefore, a great variety in the composition. Among all varieties of this series of pyroxenes, there are not two which have their bases combined in the same proportion; even pyroxenes from the same place vary in their composition: all, however, follow the law which M. Rose discovered;

* Hedenberg discovered this mineral, which he likewise first analysed. The result of his analysis is, however, very different from M. Rose's. Specimens which were obtained from Prof. Berzelius's collection were first analysed, and afterwards such as M. Rose brought with him from the place. Both analyses agreed completely in their results.

the oxygen of all the bases being equal to one half of that of the silica.

Green Malacolite from Bjormyresoeden, in Dalecarlia.

Its colour is leek-green; the powder greenish-yellow; it is semihard in a high degree; and on the edges scarcely translucent. It occurs in magnetical iron ore. The analysis gave the following result:

Silica	54·08 containing oxygen	27·20
Lime	23·47	6·59
Magnesia	11·49	4·45
Protoxide of iron	10·02	2·28
Protoxide of manganese	0·61	
	99·67	

Green Malacolite from Bjormyresoeden, another Variety.

It is scarcely different from the former in hardness, colour, transparency; in streak and lustre; it is in fact almost completely like the former. The analysis gave the following result:

Silica	54·55 containing oxygen	27·45
Lime	20·21	5·68
Magnesia	15·25	5·90
Protoxide of iron	8·14	1·85
Alumina	0·14	
Oxide of manganese	0·73	
	99·02	

Black Crystallized Pyroxene from Taberg, in Wermeland.

Its colour is raven-black; the powder greyish-green; it is semihard; opaque; occurs on a bed of iron ore with epidote, asbestos, and tremolite. The analysis gave the following result:

Silica	53·36 containing oxygen	26·84
Lime	22·19	6·23
Protoxide of iron	17·38	3·95
Magnesia	4·99	1·93
Manganese	0·09	
	98·01	

If the magnesia is not taken into consideration, this pyroxene belongs to the second division. Even in external appearance, it is like the hedenbergite, which belongs to that division.

Green Sahlite from Sahla.

The colour is light oil-green; the powder white. It gives

sparks with the steel, but with difficulty. It is in a high degree translucent at the edges. Occurs in calcareous spar. It was analysed by M. Rose, and the results obtained were:

Silica	54·86	containing oxygen	27·59
Lime	23·57		6·62
Magnesia	16·49		6·38
Protoxide of iron	4·44		1·00
Manganese	0·42		
Alumina	0·21		
	99·99		

The composition of this malacolite is, if 4½ per cent. of protoxide of iron are not taken into consideration, the same as those of the first division. Before the blowpipe also, its properties are completely like them. There occur, however, at Sahla other kinds of sahlite, which, though similar in external appearance to this, are quite different in their chemical properties and composition; while the sahlite just now described, and all other malacolites of this composition, are easily fusible before the blowpipe, these are almost entirely infusible; and if reduced powder, it merely agglutinates a little. In a small glass tube, they blacken on the first action of the flame; in the open fire, they become white.

The colour of these sahlites is the same as that of the before mentioned, but their lustre is much less, and so soft that they are scratched by the nail; while the other sahlite gives sparks with steel. They occur in carbonate of lime, and are usually penetrated by small veins of galena. The analysis of these sahlites occasioned much trouble in ascertaining their true nature.

One of the purest specimens is in the collection of Prof. Berzelius, who was kind enough to supply as much of it as was sufficient for a chemical analysis. This sahlite, after having been deprived by diluted nitric acid of calcareous spar, lost on heating in different experiments 4·15, 4·92, 4·34, and 4·11 per cent. which distinguishes it sufficiently from the common malacolite, of which the loss in the fire never amounts to one per cent.*

The powder, after being heated, had a brown-red colour, and gave the following results:

* The hard sahlite lost in the fire 0·48 per cent.; the first variety of the malacolite from Bjormyresoeden only 0·12; the second 0·22; and the hedenbergite 0·7. This latter mineral when heated in a small glass tube by the lamp of the glass blowers, gives out a sour liquid which seems to contain fluoric acid.

Silica	63·21	containing oxygen	31·79
Lime	5·18		1·45
Magnesia	26·26		10·16
Protoxide of iron	4·36		0·99
Oxide of manganese	0·82		
	99·83		

It is clear that a great surplus of silica exists in this mineral, and that it is not a bisilicate. This exception to the common rule which existed in every other analysis was unexpected. M. Rose repeated the analysis twice, but always obtained the same result. Fragments of it, when distilled in a small apparatus, gave out water, which did not change any of the test papers. M. Rose endeavoured to find fluoric acid in this sahlite by melting it with carbonate of soda, dissolving the mass in water, evaporating the liquid to a small bulk, separating it from the silica, supersaturating it with muriatic acid, mixing it with excess of ammonia, and adding muriate of lime, after which the vessel was carefully closed. No precipitate of fluate of lime appeared, not even after several days; and only a trace of silica was deposited.*

A considerable quantity of another sahlite was distilled in a porcelain retort; the loss amounted to 3·17 per cent. Water was distilled, and at last fumes passed through the aperture of the receiver, which smelt like a mixture of sulphurous and sulphuretted hydrogen. The water in the receiver was slightly sour; when saturated with ammonia, and slowly evaporated in a stove, it left only a small trace of salt of ammonia, which, when heated, evaporated like muriate of ammonia, and before the blowpipe with silica and soda, gave a brown button. By another distillation, when the receiver was kept very cold, a fluid was obtained, which, in the beginning, was turbid, smelt of sulphur, and on being saturated with ammonia, visible traces of sulphur were thrown down. When the sulphur had been separated, this solution was evaporated; the same salt remained as before, the brown colour which it communicated before the blowpipe to the glass of silica and soda, proved to be sulphate of ammonia. This sulphurous acid evidently derives its origin from the sulphuret of lead which occurs disseminated in the sahlite. The very insignificant quantity shows that it cannot be the produce of one of the constituent parts of the sahlite (the water of a perfectly pure sahlite, of which the analysis has been communicated above, did not contain any trace of it). Besides the sulphurous smell, an empyreumatic one was observed in the water, which is peculiar to the water

* When the liquid which had been separated from the silica was evaporated to a small bulk, and a mixture of sulphuric acid and alcohol poured on it, it burned with a green flame, which, however, depended upon the muriatic ether, and not on boracic acid.

obtained from all magnesian minerals, as, for example, serpentine.

It was, however, necessary to ascertain, whether the whole loss in the fire consisted of water. A quantity of another specimen was, therefore, distilled, which, in different experiments, had lost 3·09, 2·99, and 3·25 per cent. on a red heat, in a porcelain retort with a receiver, to which was adapted a tube with muriate of lime. This experiment, which was made with the greatest care, was decisive, for no gas was given out, and the loss of weight of the retort answered completely to the increase of the receiver, and the tube with muriate of lime.*

Fragments of the specimen which had served for this experiment, were employed for two different analyses. The fragments for the first analysis were taken from one end of the large piece; those which served for the second were from the opposite end. The result of these two analyses was:

Silica	58·08	containing oxygen 29·21
Lime	11·24	3·16
Magnesia with manganese	22·28	8·62
Protoxide of iron	5·30	1·20
Alumina	0·47	
	97·37	

Silica	58·30	containing oxygen 29·32
Lime	9·89	2·78
Magnesia	24·22	9·37
Manganese	0·68	
Protoxide of iron	4·24	0·96
Alumina	0·11	
	97·44	

If 3·11 per cent. of water are added, which is the mean quantity of the loss that the mineral sustained by a red heat, a small increase is obtained in the analysis. Though the oxygen in the surplus of silica is equal to that of the water obtained, and it, therefore, might appear proper to consider the hydrate of silica as isomorphous with the form of the pyroxene; yet no true hydrate of silica being either found in nature, or produced by art, there exists no reason why it should occur here. It seems as if the distinguishing property of those sahlites, which, on being exposed to heat in a covered vessel, become black, give out water,

* The quantity of purified sahlite which was used in this experiment weighed 35·916 grammes. The retort had lost 1·168 grammes; the receiver had gained 1·151,† and the tube with muriate of lime 1·009 gramme.

† The number is most probably 0·151.—*Edit.*

and are afterwards white, and which are not fusible, or whose fusibility diminishes in the same proportion as the water they contain increases, depends upon an infusible mineral, which contains water, and in the fire becomes first black, and afterwards white. Soap stone and noble serpentine are easily recognised by these properties, and these with common serpentine occurring in great quantity with the sahlite, it is clear that these varieties of sahlite are nothing but pyroxenes; that is to say, bisilicates of lime and magnesia combined with variable mixtures of soap stone or noble serpentine, of which the first is a trisilicate without water; the latter a trisilicate with water. Neither soap stone nor serpentine has the least tendency to crystallization, though both are chemical compounds; they are, therefore, no obstacle to the peculiar crystallization of the sahlite, it being already known from several examples, that both soap stone and serpentine possess a peculiar tendency to assume the crystalline form of other minerals.*

Reddish-brown Malacolite from Degaro, in Finland, analysed by Prof. Berzelius.

Silica	50·00	containing oxygen 25·15
Lime	20·00	5·62
Magnesia	4·50	1·74
Protoxide of iron	18·85	4·29
Protoxide of manganese	3·00	0·66
Loss by heating	0·90	
	97·25	

(*To be continued.*)

Article XIV.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

Jan. 23.—The reading of Mr. Macdonald's Observations on Magnetism was resumed and concluded. The principal subjects of them were the phænomena of the variation of the needle, to account for which, an hypothesis, in some respects new, was proposed by the author. It would appear, he observed, from Capt. Parry's discovery of the north-west magnetic pole, and

* M. Rose distinctly found afterwards, on closer examination, in one specimen of these sahlites, serpentine mixed with it, which, from its exterior, hardly would have been distinguishable from the sahlite, had he not supposed it to exist in the mixture.

from other circumstances, that what we call the *variation* of the needle, is, in fact, no variation at all, so that the north-pole of the earth may not, in reality, possess any magnetic attraction. The situation of the pole discovered by Capt. Parry, by a rough computation from the amount of the dip at various spots in its vicinity, as given by him, is at the intersection of 73° north latitude and 101° west longitude. Mr. M. has ascertained, that the oscillations of the needle are isochronous; and also, that when the north pole of a magnet is presented to the south pole of the needle, the oscillations describe segments continually decreasing, but are still performed in equal times: now if the north pole of the earth have any attraction, the oscillations of the needle, when upon the line of no variation in the neighbourhood of the north-west pole, which was crossed by Capt. Parry, ought to be accelerated on approaching it; and by this means the fact may be ascertained.

Mr. Macdonald supposes that the north-west magnetic pole has a rotatory motion, producing the two lines of no variation in the northern hemisphere, and that during the 159 years, from 1657 to 1816, in which the needle was advancing to the west, it described one-fourth of its orbit. This theory of the motion of the pole, he remarked, required one objection to be obviated,—the supposed solidity of the earth: but of this opinion, he stated, there was no more physical proof than of the contrary one; the subject was one of the hidden secrets of God never to be discovered. The Mosaic records indicate the earth to be full of water, contained as in a shell; and many passages of Scripture might be adduced to confirm this indication; the mode in which the earth must have acquired its figure, and several astronomical facts, likewise tend to show that it does not consist of solid matter increasing in density to the centre.

Mr. M. supposes that there is also a south-east magnetic pole, by the rotation of which the two lines of no variation in the southern hemisphere are produced; Capt. Cook came to a spot where the dip amounted to rather more than 70°; and this pole may be discovered or approximated to by sailing in the line of no variation at New Holland, as far as the ice will permit. The circumstance that the aurora borealis is never seen to rise, in Greenland, either in the north or north-west, but in the south-east or east, was cited from Crantz's History, in confirmation of this idea of a south-east magnetic pole.

In his former papers on magnetism, inserted in the Philosophical Transactions for 1796 and for 1797, the author had adopted Dr. Halley's theory of four magnetic poles; but two of these, it had since been found, did not exist where they were stated to be. In those papers, likewise, he had ascribed certain effects to the action of the sun's rays upon the earth, which, in consequence of Sir H. Davy's electro-magnetical discoveries, he was now disposed to attribute to galvanic agency; the diurnal

variation of the needle might still be connected with the influence of the sun; as, indeed, its increase from March to October seemed to prove. Mr. Macdonald further suggested, that a magnetical battery might be constructed, perhaps, by a proper arrangement of positive and negative poles; and concluded his paper with expressing his hopes, that what he had stated might lead some to pursue the subject, who were better qualified than himself for the investigation of it.

The Society then adjourned over the anniversary of the martyrdom of King Charles I.

Feb. 6.—A letter to the President from Sir Thomas Brisbane, Knt. FRS. dated Government House, Paramatta, New South Wales, Sept. 6, 1822. In this were communicated the results of the first observations made at the Observatory at Paramatta, by Mr. Charles Rumker; they related to the obliquity of the ecliptic at Paramatta, to the longitudes of Paramatta and Sydney, to the rediscovery of M. Encker's triennial comet, and to the length of Kater's invariable pendulum vibrating seconds at Paramatta.

At the same meeting was read, An Account of some Caves discovered in the Limestone Quarries at Oreston; by J. Whidbey, Esq. in a letter to J. Barrow, Esq. FRS.

The two caves described in this paper were discovered, at the elevation of 93 feet above the sea at high water in spring-tides, in the quarries upon the Cat-water, from which the stone employed in the Breakwater is procured. One was thinly lined with stalactite, and the bones it contained were imbedded in clay and rubble; in the other, they adhered to the sides; these caves communicate with each other by a sort of gallery, which opens to the face of the quarry about the size of a man's body. They have been examined by Prof. Buckland and Mr. Warburton. Their form and position were illustrated by a drawing annexed to the paper.

Annexed to Mr. Whidby's paper, was A Description of the Bones found in the Caves above-mentioned; by Mr. W. Clift, Conservator of the Museum of the Royal College of Surgeons; communicated by Sir E. Home, VPRS.

The contents of the caves discovered at Oreston in 1816 and 1820, which had been described in the Philosophical Transactions for 1817 and for 1821, were altogether different from those of the present, discovered in 1822. In the first instance, the bones all belonged to a species of rhinoceros; and in the second to a species of bear, and to an unknown antelope or deer: those now under consideration belonged to the known and existing genera of the ox, the deer, the horse, the hyæna, the wolf, and the fox. Some of them were thinly invested with stalactite, but the greater number were firmly imbedded in clay. None had been gnawed, except the radius of a young wolf, which presented traces of the canine teeth and incisors, of an animal apparently

about the size of a weasel. The bones of the various graminivorous animals were found together; but those of the carnivora at a distance from each other. All were very fragile and white; some were treated with muriatic acid, and found to have lost nearly all their animal matter; while others examined by Prof. Buckland retained about one-third less than those of Kirkdale. The proportion of animal matter retained by fossil bones, varies very considerably in different specimens. In the Museum of the Royal College of Surgeons, there are some teeth of the mastodon, from the banks of the Ohio, which have been deprived of their earthy matter by means of muriatic acid, but still showing their whole form. Mr. C. suggested, that the clay in which the Oreston bones were found, and which, in their immediate vicinity, was much blacker as well as more tenacious and solid than in any other part, might have abstracted the animal matter from them. They are so absorbent of moisture, that the largest adheres to the tongue with sufficient strength to support its whole weight. When immersed in water, much effervescence took place, and the bones became black; but resumed their usual appearance on being dried; this was particularly the case with those of the carnivorous animals. In consequence of their fragility, some of them were broken by the workmen while divesting them of the clay; while others fell to pieces on being exposed to the air. In respect to the latter circumstance, they resemble the tusks, &c. of the elephant, found in the sand above the blue clay at Brentford, Ilford, and other places near the river Thames, which divide into lozenge-shaped or into cubic fragments.

Fossil bones showing traces of disease, Mr. Clift observed, are extremely rare; and he has never seen any that exhibited fractures which had been healed during the life of the animals: there are, however, among these from Oreston, the metacarpal and metatarsal bones of an ox, which bear evidences of ossific inflammation; and the lower jaw of a young wolf, in which two abscesses, one on each side, have produced sinuses.

The fragments of shell found in one of the caves, retain their pearly matter, and appear to be those of an ostrea; but they are too small to present any satisfactory characters, not amounting to the bulk of a single valve.

A more particular description of the bones, illustrated with drawings, succeeded the above observations. There are bones of about twelve oxen, with short conical horns, standing upright; and larger than the medium size of the existing species of that genus. A few seem to belong to a deer, but this cannot be satisfactorily determined, as there is neither the head of the animal, its horns, nor its teeth. Some small bones of a young animal, apparently a calf or a fawn. The bones and teeth of about twelve horses, which must have been fourteen hands high. The bones of five or six hyænas, including two jaw-bones with

teeth. The bones of several wolves, of the same size as those of the existing species. The whole of these remains have been deposited in the Museum of the Royal College of Surgeons, by Sir E. Home.

Some further particulars of the quarry and caves, by Mr. Whidbey, were appended to Mr. Clift's paper. Mr. W. stated, that no more bones were likely to be discovered; for the rock containing the caves was very nearly worked out; and he expressed his opinion, that no communication had existed between the caves and the surface of the country since the Flood.

Feb. 13.—A Letter to the President from T. Young, MD. Foreign Secretary to the Society, was read: it related to Mr. Rumker's rediscovery of Prof. Encker's little triennial comet, near the place which the Professor had assigned to it by compution. Mr. Rumker first observed it on the 2d of June last, and it continued visible until the 23d, when it was lost in the light of the moon, and it could not afterwards be discovered.

At this meeting, also, part of a paper by Mr. Goldingham was read, relating to Experiments on the Velocity of Sound, made at Madras.

Article XV.

Scientific Intelligence, and Notices of Subjects connected with Science.

I. *Splendid Meteor seen on Oct.* 28, 1822. By Mr. Davenport.

(To the Editor of the *Annals of Philosophy.*)

SIR, *London, Jan.* 18, 1823.

Will you allow me room in your publication to inquire whether any of your correspondents witnessed an extraordinarily fine meteor that appeared on the 28th of last October?

I was travelling northward on the Hastings' road, and going slowly up Silver Hill, which is about 48 miles south-east of London, by road measurement, at about half-past five on the above-mentioned day, the sky being clear, the moon shining bright, and nearly full, the sun below the horizon, but the twilight still strong; I saw on a sudden in the sky about north-east, a luminous ball, of full one-third the apparent diameter of the full moon, giving a remarkably bright and white light. Its height above the horizon I consider to have been about 22°; but being myself on a steep ascent, I could less easily judge of this. It passed towards the west in a horizontal direction, and the line of its motion, while I saw it, subtending an angle of above 20°, during about eight seconds of time. Unfortunately, it passed behind a loaded waggon; but as I pushed on to regain the view of it, I thought (but was not certain) that I saw a faint remainder of it for an instant.

If this meteor should have been observed from any distant place, so

that by comparison of the apparent motion, direction, and bearings, its height above the earth can be estimated, I will endeavour, when I revisit the spot, to ascertain its relative bearings and apparent altitude with greater accuracy; as I can fix on the spot on the road from which I viewed it, and also on the objects in the line over which I traced it.

I am, Sir, your obedient servant,

Richard Davenport.

II. *Analysis of the Ashes ejected from Vesuvius, during the late Eruption.* By Prof. V. Pépé, of Naples.

In ten ounces of these ashes, which correspond to 6000 grains, there are, according to this extraordinary analysis, 186 grains of saline substances, viz.

Sulphate of potash	9½
Sulphate of soda	44
Sulphate of lime	57
Sulphate of magnesia	16
Sulphate of alumina	14
Hydrochlorate of potash	9
Hydrochlorate of soda	31
	180½
Loss	5½
	186

Oxide of aluminium	1800
Oxide of calcium	300
Oxide of silicium	1200
Oxide of magnesium	300
Tritoxide of iron	1800
Antimony	360
Gold	13½
Silver	6½
	5966
Loss	34
	6000

However scrupulously the distinguished Professor has occupied himself in the search of other substances, he has not been able to find any more!—(Giornale delle due Sicilie, Nov. 15, 1822.)

III. *Tutenag and White Copper of China.*

In the *Annals* for Sept. last, vol. iv. p. 236, we gave from No. 13 of the Edinburgh Philosophical Journal, Dr. Fyfe's analysis of the tutenag or white copper of China. In the original paper, Dr. F. commences with some remarks on the very different statements which have been made respecting the composition and origin of tutenag; but it now appears that these may have arisen from the circumstance, that the two appellations have been applied promiscuously to two distinct substances. In No. 15 of the Edinburgh Journal are some observations

on the subject by Sir T. Dick Lauder, Bart. FRSE. in which he states, on the authority of a friend employed for many years in the trade between China and India, "that the substance analyzed by Dr. Fyfe is not tutenag, but white copper, the properties of which are totally different;" and he then proceeds as follows:

"The white copper is used by the Chinese themselves, who are so jealous of permitting other nations to have it, that its exportation is contraband. In defiance of this, however, considerable quantities of it are smuggled out of the country, and introduced into India, where it is considered as a great present to the Hindoos, &c. who make domestic vessels of it. The tutenag, on the contrary, is an article of very extensive commerce between China and India; and my friend informs me, that it is sent from China in slabs, of which he has had occasion to buy and sell many thousands. The slabs are about eight or nine inches long, by about five and a half wide, and about five-eighths thick. Its colour is greyish; and it is not malleable, but so brittle that it is even necessary to use considerable caution in putting it on ship-board, to prevent its being broken by one piece striking against another. The fracture has a glittering lustre, and somewhat resembles the appearance exhibited by that of bad iron; but the crystallization (if such a term may be employed) is larger. It does not ring, but emits a heavy clattering sound. It is employed by the natives of India as an alloy for copper, to make brass for their domestic utensils."

Article XVI.

NEW SCIENTIFIC BOOKS

PREPARING FOR PUBLICATION.

Dr. Baron, of Gloucester, has undertaken to write an Account of the Life of the late Dr. Jenner, and to arrange for publication the manuscripts of that distinguished character; for which purpose all the documents in possession of the family, have been committed to his care.

Mr. Thomas Clarke is preparing for publication a new System of Chemical Nomenclature, exhibiting not only the component Parts of Compound Substances, but also the precise Proportion of these Parts.

Sir W. Gell has in the press, a Narrative of a Tour through the Morea, giving an Account of the present State of that Peninsula, and its Inhabitants.

JUST PUBLISHED.

The Encyclopædia Metropolitana, Part 8. 4to. Price 1l. 1s.

An Inaugural Lecture on the Study of Chemistry, read at the Ashmolean Museum, Nov. 2, 1822. By Charles Daubeny, MD. FRS. MGS. Professor of Chemistry, and Fellow of Magdalen College, Oxford.

The British Flower Garden. By Robert Sweet. No. I. with Four coloured Plates, from Drawings by E. D. Smith. Price 3s.

Article XVII.

NEW PATENTS.

H. Ibbotson, Sheffield, fender-manufacturer, for a fender capable of being extended or contracted in length, so as to fit fire-places of different dimensions.—Nov. 28.

J. Dixon, Wolverhampton, Staffordshire, brass-founder, for improvements on cocks, such as are used for drawing off liquids.—Nov. 28.

J. Woollams, Wells, Somersetshire, land agent, for improvements in wheeled carriages.—Dec. 5.

W. Robson, St. Dunstan's-hill, Tower-street, printer and stationer, for a method to prevent or protect against fraudulent practices upon bankers' checks, bills of exchange, and various species of mercantile, commercial, and other correspondence.—Dec. 10.

J. Perkins, Fleet-street, late of Philadelphia, engineer, for improvements in steam-engines. Communicated to him by a foreigner.—Dec. 10.

S. Parker, Argyle-street, Westminster, bronzist, for improvements in the construction of lamps.—Dec. 10.

W. Bundy, Fulham, Middlesex, mathematical instrument maker, for a machine for breaking, cleaning, and preparing, flax, hemp, and other vegetable substances containing fibre.—Dec. 16.

T. B. W. Dudley, King-street, Westminster, mechanist, for a method of making or manufacturing malleable cast-metal shoes for draft and riding horses, and other animals, upon a new and improved plan or principle.—Dec. 16.

J. Nicholson, Brook-street, Lambeth, engineer, for apparatus for the more conveniently applying heat to certain instruments of domestic use.—Dec. 16.

J. Dumbell, Howley House, Warrington, Lancashire, merchant, for improvements relative to carriages.—Dec. 16.

J. Bainbridge, Bread-street, Cheapside, merchant, for improvements on rotatory steam-engines. Communicated to him by Amos Thayer, jun. of Albany, America, mechanist.—Dec. 16.

M. Wilks, Dartford, Kent, seed-crusher, for a new method of refining oil produced from seed.—Dec. 20.

T. Linley, Sheffield, Yorkshire, bellows-maker, for a method of increasing the force or power of bellows.—Dec. 20.

Sir J. Jelf, Oaklans, Gloucestershire, for a combination of machinery for working and ornamenting marble and other stone for jams, mantles, chimney-pieces, and other purposes.—Dec. 20.

J. I. Hawkins, Pentonville, civil engineer, and S. Mordan, Union-street, City-road, portable pen-maker, for improvements on pencil-holders, or port crayons, and on pens, for the purpose of facilitating writing and drawing.—Dec. 20.

W. Fiss, Curtain-road, Shoreditch, dyer, for an improvement in calcining and smelting of various descriptions of ores.—Dec. 20.

Article XVIII.

METEOROLOGICAL TABLE.

1823.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.	Daniell's hyg. at noon.
1st Mon.								
Jan. 1	Var.	29·94	29·91	37	29	—	—	
2	S E	30·02	29·94	44	36	—	25	
3	S E	30·02	29·93	44	36	—	—	
4	S E	29·93	29·91	40	37	—	26	
5	S E	30·03	29·91	43	37	—	25	
6	S	30·25	30·03	45	35	—		
7	N E	30·30	30·25	41	32	—		
8	N E	30·25	30·16	40	20	—		
9	N E	30·16	30·05	32	21	—		
10	E	30·07	30·05	33	23	—		
11	N E	30·09	30·08	31	22	—		
12	N E	30·08	29·88	30	19	—		
13	N E	29·88	29·78	30	15	—	—	
14	E	29·78	29·48	31	14	—		
15	N E	29·55	29·48	31	20	—	—	
16	N W	29·58	29·55	34	26	—	—	
17	N W	29·58	29·57	34	26	—		
18	N W	29·69	29·57	34	6	—		
19	S W	29·89	29·69	19	4	—		
20	N W	30·05	29·89	32	19	—	—	
21	N E	30·13	30·05	33	22	—		
22	N E	30·13	30·02	28	20	—		
23	E	30·02	29·96	27	21	—		
24	N E	30·01	29·96	30	20	—		
25	E	30·01	29·98	28	22	—	—	
26	N E	29·98	29·89	31	25	—		
27	S E	29·89	29·68	40	29	—	—	
28	S W	29·68	29·33	46	42	—	1·05	
29	S E	29·56	29·33	50	39	—	04	
30	S W	29·56	29·34	46	40	—	—	
31	E	29·34	28·97	41	37	·42	·20	
		30·30	28·97	50	4	·42	2·05	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

First Month.—1. Cloudy. 2. A gentle thaw with some rain. 3. Fine. 4. Cloudy. 5. Rainy. 6—8. Fine. 9. Hoar frost: fine. 10. Cloudy. 11. Fine: afternoon overcast. 12. Bleak. 13. Some snow this morning. 14. Fine. 15. In a heavy snow which commenced this morning, a flock of some hundreds of wild geese passed over us about 11, a. m. steering their course to the east. The snow fell to about four inches depth on the level. 16. Some snow at 10, p. m. 17. Cloudy. 18—20. Much rime on the trees; which, being rather loosely attached, a part fell as it collected, forming a regular snow shower under the trees: the latter nevertheless retained at length a sufficient quantity of the icy foliage to enable them to cast a full shadow on the ground as in summer, which had altogether a singular appearance. 21. Fine. 22—24. Cloudy. 25. It began to snow at three, p m. and the fall continuing through all the night, covered the ground to five or six inches on the level. 26. Cloudy. 27. Some hail at nine, a. m. followed by rain, which continued till near four, p. m. 28. Rain. 29—31. Cloudy. During the intense cold of the month, much ice accumulated in the Thames, the navigation of which was for some considerable time suspended for the smaller vessels. The feathered tribes exhibited in various ways the appearance of distress usual with them on such occasions by changing their quarters, and seeking food nearer than usual to the houses and villages.

RESULTS.

Winds: NE, 11; E, 5; SE, 6; S, 1; SW, 3; NW, 4; Var. 1.

Barometer: Mean height

For the month.. 29·854 inches.

For the lunar period, ending the 4th .... 30·287

For 13 days, ending the 2d (moon north) .... 30·239

For 14 days, ending the 16th (moon south).......... 29·946

For 13 days, ending the 29th (moon north) .... 29·826

Thermometer: Mean height

For the month.. 30·629°

For the lunar period.. 33·166

For 30 days, the sun in Capricorn .... 29·383

Evaporation.. 0·42 in.

Rain. .... 2·05

Laboratory, Stratford, Second Month, 22, 1823. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

APRIL, 1823.

ARTICLE I.

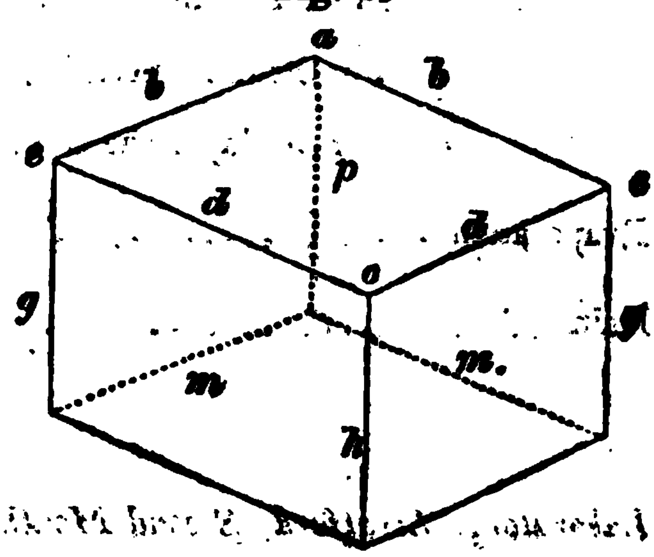
Description of a new Mineral. By Mr. A. Levy, MA. of the University of Paris.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Great Russell-street, Bloomsbury, March 3,* 1823.

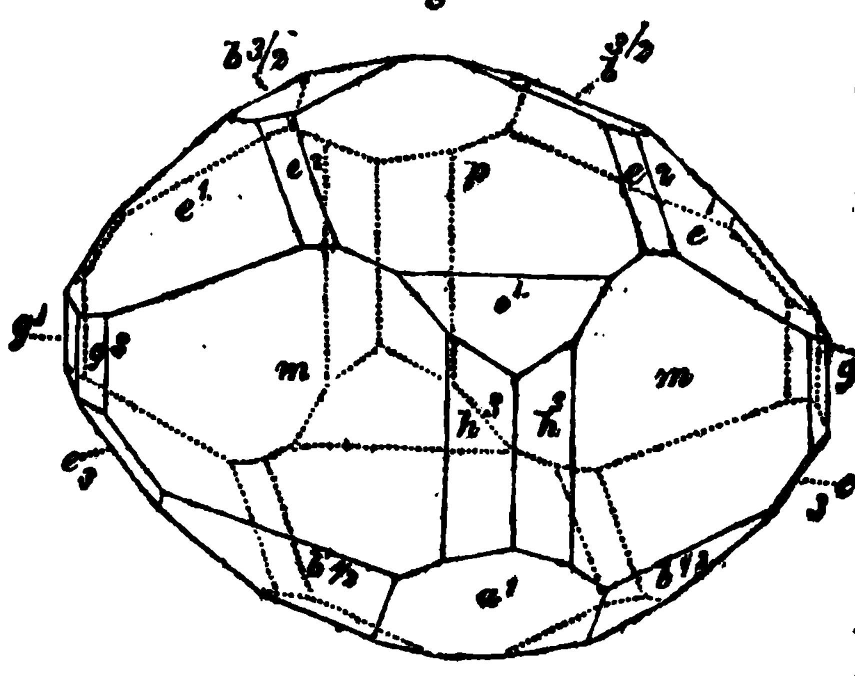
I SHALL again beg the favour of your inserting in the *Annals of Philosophy* the crystallographical description of a mineral which I cannot refer to any substance whose primary form has been determined hitherto. It occurs in small brilliant yellowish-brown crystals, with adularia and lamellary crichtonite, and comes from Dauphiny. On account of its colour, accompaniment, and locality, it has been classed with sphene; but as it will appear from what follows, it differs essentially from this last substance. Its hardness is much less than that of sphene; it cleaves very easily in one direction, and the face of cleavage is perfectly brilliant. The primary form is an oblique rhombic prism, fig. 1, in which the incidence of the two lateral planes *m*, *m*, is 96° 10′, that of the base *p* on one of the lateral planes 99° 40′, and the ratio between one side of the base and one of the lateral edges nearly that of 10 to 7. The primary form of sphene is also an oblique rhombic prism, but its dimensions are different. The incidence of the two lateral

Fig. 1.



planes is 137° 5′, and that of the base on one of the lateral planes 94° 3′. Sphene presents in the series of its secondary forms many oblique rhombic prisms, the lateral planes of which are produced by modifications either on the lateral edges, two of the sides of the base, or the lateral angles; and the base is, either the base of the primary or some secondary plane produced by a decrement on the angles a or o. None of these secondary oblique rhombic prisms that I have observed, nor any of those mentioned by Mr. Rose in the excellent paper on sphene, he has published at Berlin, have their planes inclined at the same angles as those of the primary of the substance I am describing. The secondary oblique prisms of this substance do not either in their measurements correspond with any of the oblique rhombic prisms of sphene. I have also tried whether I could not deduce by some law of decrement, the form of this new substance from the primary of sphene, and I have found it was not possible without assuming very complicated laws. I believe, therefore, I am entitled to consider it as a new species. Mr. Heuland has proposed to me to call it *Turnerite*, from the name of the gentleman in whose collection it was first noticed as a distinct species. This tribute is certainly well due to Mr. Turner, who has undertaken with so much readiness and liberality the publication of a detailed description of his most valuable collection. This new substance is very scarce, and besides the specimen where I have observed it, Mr. Heuland knows but one more in England. I could only detach a single crystal of it, and, therefore, could not attempt to determine its specific gravity, or to have it analysed. I hope the observations I have made may induce some others to examine the physical and chemical properties of this substance, should they be able to procure it, and it is partly for this motive I publish them now.

Fig. 2.



The form of the crystal I have examined is represented, fig. 2; its planes were sufficiently brilliant to measure the incidences of any two of them. The reasons for which I took the planes m, m, in preference to the planes marked $b^{\frac{1}{2}}$, for the lateral planes of the primary form, are obviously, that in the hypothesis I have made, the planes g^3, h^3, are the result of simple decrements on the lateral edges of the primary, and that in the other supposition, they would have

been the result of intermediary decrements. For a similar reason relative to the face e_3, I have determined the ratio between the lateral edge and one side of the base by assuming e^1 to be the result of a decrement by one row on the lateral angles of the base. The cleavage I have mentioned before is parallel to a plane passing by the two small diagonals of the bases. The decrements which produce the other faces are indicated by the signs written upon them; and their incidences upon p or m are as follow:

	Incidence on m.	Incidence on p.
m	96° 10′	99° 40′
$b^{\frac{1}{2}}$	140 50	119 30
$b^{\frac{3}{2}}$	106 28	153 52
e^1		137 22
e^2		155 17
e_3	144 51	110 11
a^1		127 35
o^1		142 29
h^3	162 15	
g^3	161 2	
g^1	131 55	90 0

It will not be, perhaps, useless to remark, that in the oblique rhombic prism I have adopted for the primary form, the line joining the angle o with its opposite is not perpendicular to the edge h. A perpendicular drawn from o upon the edge opposed to h would cut that line at a distance from a, a little less than the two-thirds of the length I have assigned to it.

I am, yours, &c. A. Levy.

Article II.

Researches into the Mathematical Principles of Chemical Philosophy. By the Rev. J. B. Emmett.

(*Concluded from* vol. iii. N. S. p. 433.)

Great Ouseburn, Feb. 22, 1823.

Sect. II. On the Construction of Liquids.

Lemma 1.—When the repulsive force of heat in a solid exceeds the force of cohesion, its particles will be separated from each other.

Lemma 2.—If there be two curves having a common axis, and on the same side of it, whose ordinates are inversely as some given powers of their abscissæ; that curve whose ordi-

nates vary inversely as the highest power of the abscissa, will either lie wholly between the other curve and the common axis, or will intersect it in one point.

Lemma 3.—If the force of attraction vary inversely as any power of the distance, and there be two equal and parallel planes; when the distance between them is very small, their mutual attraction varies as the same power of the distance inversely, the force belonging to the surface only.

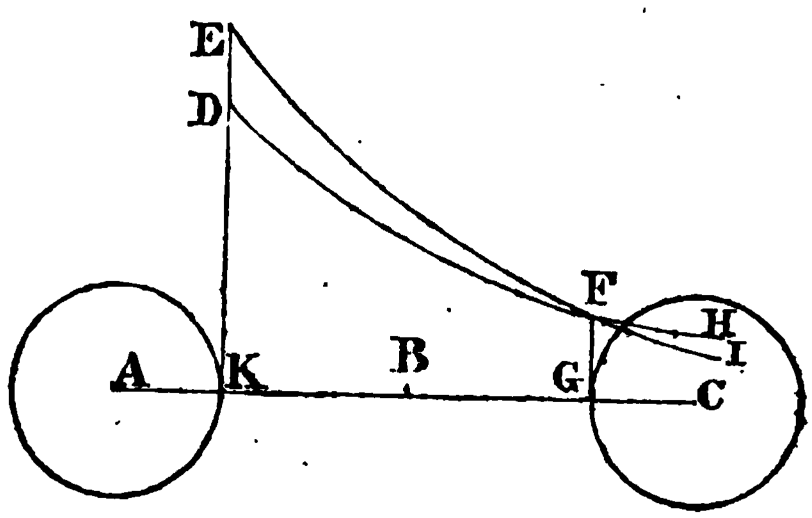
This follows from lib. 1, Prop. 90, Newt. Princip. by placing instead of a corpuscle at P, a plane parallel to D L, and making the distance A P very small.

Cor. 1.—If the force of such planes be finite at any finite distance, it will be infinite in contact.

Cor. 2.—The same applies to spheres of indefinitely small magnitude, the force belonging to the surface only; in contact it will not be infinite.

Prop. I.

When the particles of a solid are separated by the force of heat, they remove to such a distance from each other, that the force of attraction at that distance balances that of repulsion, and the body becomes fluid.



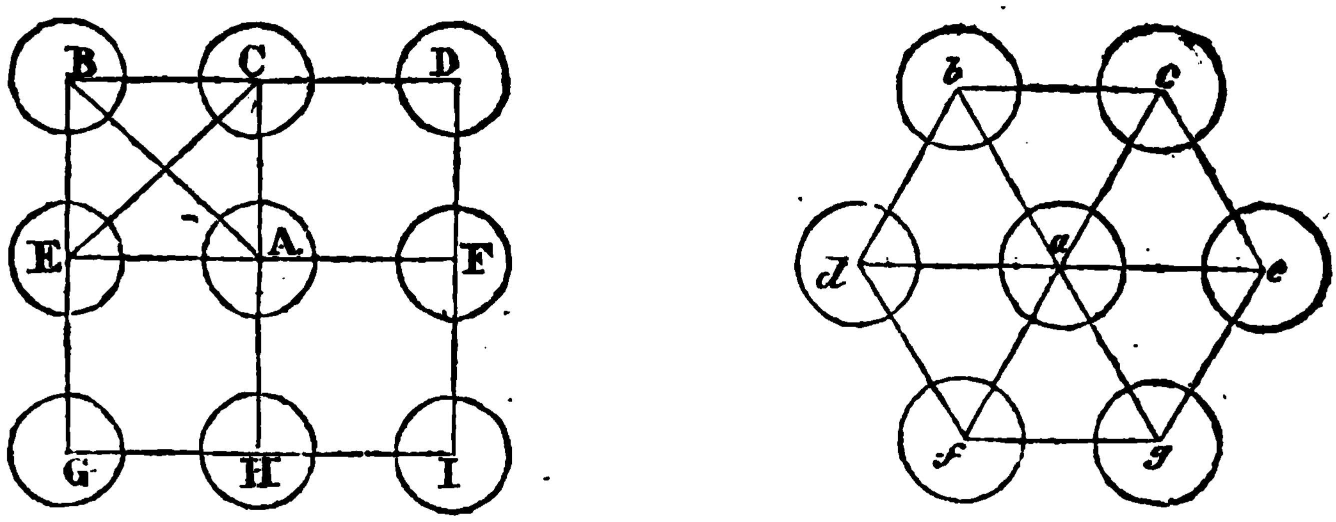
Let A C be two equal and similar particles of matter; while they are in contact with each other, the force of cohesion exceeds that of repulsion; let the repulsive force of heat be increased until it overcomes the cohesion; the particles will separate (Lemma 1), but the force of cohesion is indefinitely greater than the attraction of the particles at the least possible distance, and vanishes when contact of the particles ceases; therefore A and C become repulsive. Join A C, and bisect A C in B; describe the curve D F H such that its ordinates are as the forces of attraction at the distances represented by their respective abscissæ; at K erect the perpendicular E K, and D K is the entire force of attraction at K, except cohesion. Take E K to D K, as the force of repulsion in contact is to that of attraction, and describe the curve E F I such, that its ordinates F G are always as the force of repulsion; that is, as the density of the calorific atmospheres at B; this curve approaches A C more rapidly than the former, but E K is by the hypothesis greater than D K; therefore (Lemma 2), the curves will intersect each other, or the forces will be equal at some given point F; let fall the perpendicular F G, and the particles will be in equilibrio at

the distance K G; for at G the ordinates of the two curves are equal; therefore, the opposite forces are equal to each other: also between G and K the force is repulsive; beyond K, it is centripetal; therefore, the temperature being uniform, the distance between the particles can be only K G, and they are there in equilibrio between two opposite forces; therefore, they have perfect freedom of motion round each other; and a number of such particles will constitute a liquid. Q. E. D.

Cor.—Under atmospherical pressure, the distance K G will be diminished, so that the excess of the force of repulsion above that of attraction shall equal the pressure.

Prop. II.

To find the order of arrangement of the particles of a liquid.



Let there be a system of detached particles, B, C, A, F, &c.; join their centres B C, C A, A B, &c.; arrange them so that the lines B C, C A, A E, &c. which join the centres of contiguous particles may form squares B A, C F, &c. By the nature of the figure, A is surrounded by the greatest possible number of particles under the given arrangement. Suppose the forces acting between B and C, C and A, A and E, &c. mutually to balance each other, then A and B, C and E, &c attract each other (Prop. I.); and since A B is equal to C E, the arrangement of the system may remain; but if by any disturbing force, B be brought nearer to A, since the distances B C, C A, &c. must remain permanent, B will continually approach towards A; E and C must recede from each other, until their mutual attracting forces balance their repulsion; i. e. when B A is equal to C A, when also C E is equal to 2 C A; consequently when the triangles B C A, B E A, are equilateral. Similarly, since the position of C is changed, the equilibrium of C D F A is destroyed, and the particles D and F will assume the same order of arrangement; and the same change must take place throughout the whole system. Again: by the same reasoning, if B and A, C and E, are in equilibrio, B and C, C and A, &c. will be mutually repellent; and finally, if disturbed, assume the same order. Therefore, their arrangement *a*, *b*, *c*, *d*, &c. becomes such that the straight lines *a b*, *b c*, *c a*, &c. joining their centres, form equila-

teral triangles, in which equilibrium is preserved; for since the particles are equal and similar, and *a*, *b*, mutually balance each other, *b* and *c*, *c* and *a*, are in equilibrio; and if *c* be brought nearer to *b* or *a*, it is repelled (Prop. I.); if removed to a greater distance, it is attracted; therefore the triangles *a b c*, *a c e*, &c. will be equilateral. Q. E. D.

Prop. III.

Liquids will be expanded by heat and contracted by cold.

It has been demonstrated in a former paper that by increasing the heat, the repulsive force of every calorific atmosphere is increased; and upon the surface of a particle of a liquid, it exceeds the force of attraction. Hence (Lemma 2), the distance of the point in which the forces are in equilibrio is increased; therefore the particles separate. Conversely, diminish the heat, and the particles approach, or, in other words, the volume contracts. Q. E. D.

Prop. IV.

Solids absorb heat during fusion.

By Prop. 1, the particles separate during fusion; hence the calorific atmospheres are enlarged, and particularly where they are most dense; therefore, caloric will be absorbed. Q. E. D.

Cor. 1.—Hence, during fusion, some bodies will absorb more heat than others.

Cor. 2.—The proportionate quantities absorbed during the fusion of different solids are measured not by equal weights, but by weights which are proportional to the atomic weights.

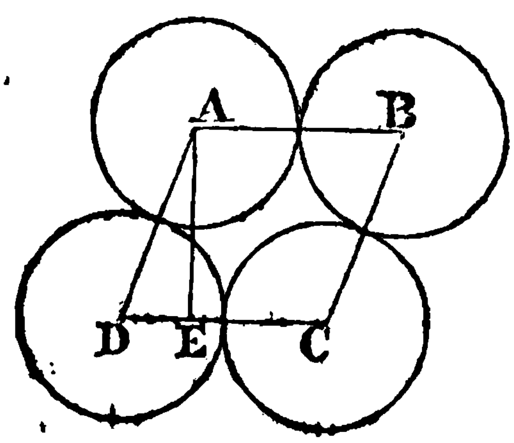
Cor. 3.—Hence solids fuse gradually, and the temperature remains constant during fusion.

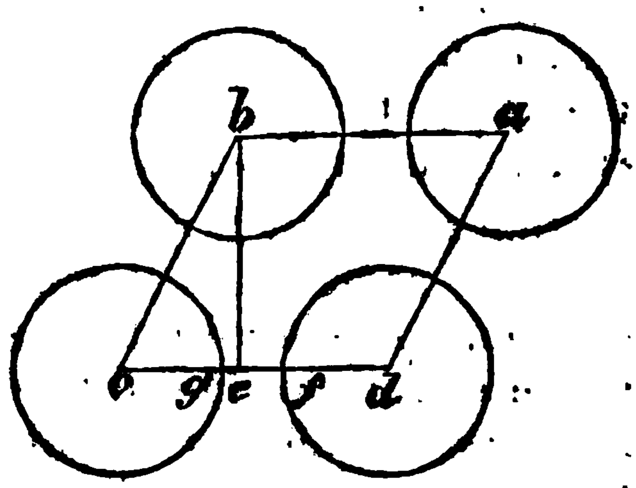
Cor. 4.—Hence the temperature of a solid cannot be elevated above a certain point.

Cor. 5.—Hence the reason of the operation of that class of frigorific mixtures which depends upon the solution of crystals of saline matter.

Prop. V.

Some bodies expand, others contract, during fusion.





Let A, B, C, D, be four particles of a solid; join their centres,

and from A, let fall the perpendicular A E; let the angle A D C be that which the parallelogram has, when the particles are on the point of separating from each other. When they have separated, as *a, b, c, d*, the angles are 60° and 120° respectively (Prop. II.); let *f g* be the distance to which they separate (the liquid having the same temperature as the fusing solid); from *b* let fall the perpendicular *b e*, which bisects *g f* and *c d*.

The solid A B C D : solid *a b c d* :: $DC \times AE^2 : dc \times be^2$, or as $AD \times AE^2 : \{AD + fg\} \times be^2$; but $be : bc$ in a constant ratio; let $be = \frac{bc}{n}$; that is $= \frac{AD + fg}{n}$; therefore, solid A B C D : solid *a b c d* :: $AD \times AE^2 : \frac{\{AD + fg\}^3}{n^2}$. Now $AD \times AE^2$ may have any value between AD^3 and $\frac{3 . AD^3}{4}$; while $\frac{\{AD + fg\}^3}{n^2}$ is always $\frac{3\{AD + fg\}^3}{4}$, which may be greater or less than the former according to the value of *f g*; therefore, since these quantities admit of indefinite variation, some bodies will expand, and others contract. Q. E. D.

Prop. VI.

Liquids will be attracted by solids.

It has been proved (Prop. I), that beyond a certain distance, the entire force exerted by the particles of a liquid is centripetal; at all distances the centripetal force of the particles of a solid exceeds the repulsive; therefore, the two will attract each other. Q. E. D.

Cor. 1.—If the mutual attraction of the particles of a liquid exceeds their tendency to a solid, a small drop will retain nearly a spherical figure upon the surface of that solid.

Cor. 2.—If the mutual attraction of the particles of the liquid be less than their attraction to the solid, the drop will spread upon its surface.

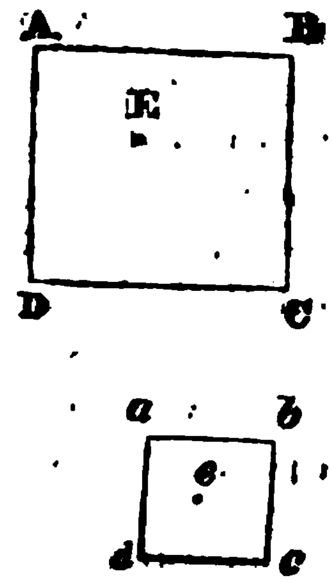
Cor. 3.—Hence in Cor. 1, a small mass of a solid specifically heavier than a liquid may be made to float upon its surface.

Cor. 4.—If two drops of a liquid, constituted as in Cor. 1, be placed upon a horizontal polished surface, and very near together, they will attract each other and unite.

Cor. 5.—If two liquids be mixed, of which the similar particles attract each other more powerfully than the dissimilar, and which differ in specific gravity, they will separate again.

Prop. VII.

If a porous solid be moistened with a liquid, the liquid will cause expansion of the solid; and if equal solids be taken, having unequal pores, the entire expansive forces upon equal surfaces will be inversely as the diameters of the pores; the solid being insoluble.



Let A B C D be a capillary pore in any solid; take E any point within it; immerse the solid in the liquid; it attracts those parts of the liquid which are within a certain minute distance from the surface; these parts tend to enter at E; and since the force of attraction is inversely as the square of the distance, and all liquids are incompressible, or indefinitely nearly so, the tendency will be inversely as the distance of E, and the whole force upon one side of that pore will be as that side directly and its distance from E inversely. Take *a b c d* similar to A B C D, and *e* similarly situated to E; the tendency of the liquid to enter at E : that at *e* :: *a b* : A B; but the area of one side A B : area of one *a b* :: $A\,B^2 : a\,b^2$; therefore the whole force upon the side A B : that upon *a b* :: A B : *a b*: now if equal solids be taken, the number of such pores contained under equal sections will be inversely as the square of the homologous lines of those pores; hence the whole expansive force acting upon equal surfaces will be inversely as the diameters of the pores. Q. E. D.

Cor. 1.—In different substances, the force will be as the actual attraction existing between them and the liquid directly, and the magnitude of the pores inversely.

Cor. 2.—When an insoluble solid is immersed in a fluid, if the tendency of the liquid to enter its pores be greater than its cohesive force, its parts will be separated.

Scholium.

By Lemma 2, we may see the reason why corpuscular forces are so great as they are found to be, and why the forces are corpuscular. The demonstration of this and several other parts is omitted for the sake of brevity, and they will subsequently appear as a separate work in an enlarged form. From this the reason is evident why an elastic fluid of so amazingly great rarity as caloric can produce the observed powerful effects; for distances from the surface of a particle being taken in harmonical progression, the repulsive force of the calorific atmosphere decreases in geometrical progression, and therefore distances may be found, such, that this may equal any finite force. Upon the same principle depends the immense force of water when admitted into the capillary apertures of porous solids.

Other curious phenomena admit of easy solution. From the great tenacity of melted glass, it appears that the utmost limit of expansion is produced before the glass is melted; that is, when the angles A, B, C, D (Prop. V.) have become right angles, the particles are yet preserved in contact by a powerful cohesive force. On account of this tenacity and the great rapidity with which it increases as the temperature is reduced, the particles cannot readily yield to any force which may be impressed upon

them; if the glass be unannealed, i. e. allowed to cool rapidly, it hardens rapidly, and the particles cannot return to that position in which they would be placed were the cooling very gradual: hence, from a former paper, the particles may have the same position when cold which they had in a fluid state; but if the place of one particle be disturbed, the equilibrium of the whole system will be destroyed, and the mass, however large, will be broken to pieces, by the action of a small piece of any hard matter: hence the peculiar properties of bottles of unannealed glass, Prince Rupert's drops, &c. Also, owing to the great tenacity of glass at the annealing temperature, by that process, the particles can never assume that position in which their attracting forces tend to place them; hence then they will always have a tendency to change, when the situation of a part is altered; the cutting diamond may depend upon this principle.

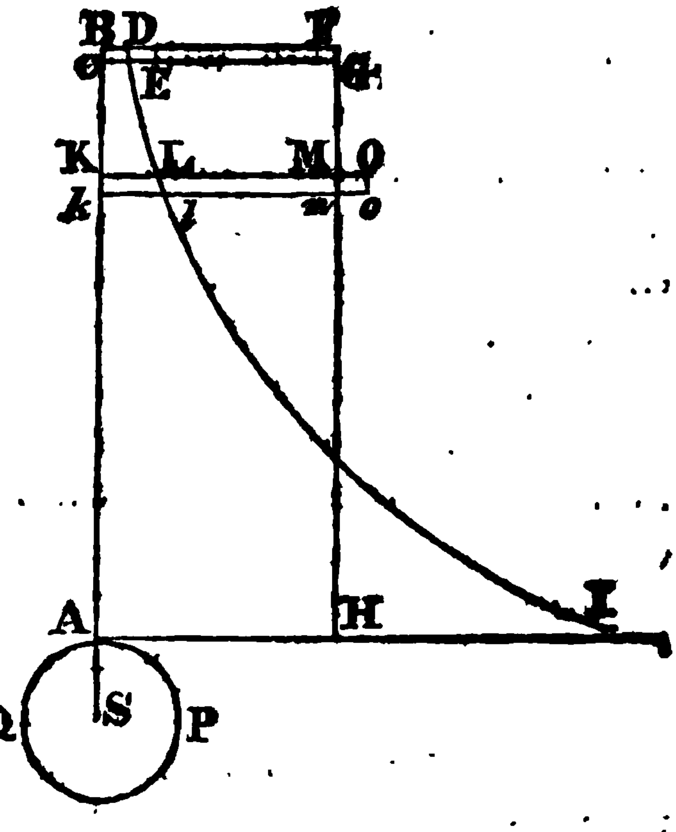
The mechanical properties of liquids prove that the repulsive force of heat decreases more rapidly than the centripetal force. The parts of a liquid have perfect freedom of motion, therefore the particles cannot touch each other; since they are at a certain distance from each other, which is permanent, the temperature being constant, they must be in equilibrio between two opposite forces, which are equal at that distance. If the force of repulsion vary less rapidly than the other, there may be a distance at which the two forces are equal; but if two particles under such circumstances be disturbed, the equilibrium is destroyed, and, if brought nearer, they will come into contact; if removed to a greater distance, they will separate indefinitely, which is contrary to the fact: if the force of repulsion vary most rapidly, both forces, Prop. I. will tend to that point, so that the particles can be only at that distance from each other. Again: if the repulsive force vary less rapidly than the other, increase of heat would cause contraction, and *vice versâ*, which is absurd.

Cor. 2, Prop. VII. shows why dry unbaked clay, white lead, prussian blue, and many other solids, insoluble in water, are reduced to a paste when immersed in it; these substances are well known to be sensibly porous, and it is evident that the force with which the water tends to enter into and expand the pores, exceeds the cohesive force of those solids.

The tenacity of moist clay results from a similar cause. Clay also will contract permanently by the application of heat. By the first application of heat, the water contained in the clay will be expelled: it is then filled with minute pores; if the temperature be increased, the force of cohesion is considerably diminished, and the sides of the pores will have a tendency to approach each other; consequently the volume will contract, and the contraction will be permanent.

Sect. III. On Gaseous Bodies.

Lemma.



In distances from the particles of bodies, such, that the increase of density of the surrounding caloric is very small compared with its entire density. If the force of attraction vary inversely as the nth power of the distance, and the elastic force of caloric be as its density, the repulsive force of the calorific atmosphere will be inversely as the $\overline{n-1}$th power of the distance.

Let A P Q be a particle of matter; produce the radius A S indefinitely; describe the curve D L I, such that its ordinates B D, K L, &c. perpendicular to B S, shall be proportional to the force of attraction at B, K, &c. Let this particle be immersed in an uniformly diffused elastic medium, whose density is B F; at remote distances A, K, the pressure on K : pressure on k :: S k : S K.

Through the point F draw F H parallel to B S, and if the medium were not attracted by A P Q, its density at all points A, K, B, &c. would be equal to B F. Take C indefinitely near to B; the specific gravity of the elastic medium at B is as B D × B F; therefore its pressure at C is as B D × B F × B C; if this pressure be indefinitely less than the whole elastic force of the fluid, its density will be increased by this pressure, by a quantity which is indefinitely small, compared with the whole density, or the fluid may be considered as incompressible by the force acting upon it. At the point K, let the density K M be increased by the superincumbent pressure, by the quantity M O, and let M O be very small compared with K M; through k draw k o parallel to K O, and O o parallel to K k; the evanescent area K m will be less than the evanescent area K o by the indefinitely small area M o; therefore the pressure K L × K M × K k is less than the pressure K L × K O × K k by the quantity K L × M O × K k, which is indefinitely small when compared with either; therefore the pressure at k will be indefinitely nearly equal to the sum of all the several pressures K L × K k × B F, C E × B C × B F, &c.; that is, as the area k B D l × B F. Let the force of attraction be as $\frac{1}{AB^n}$, and the

lines L D, S B, be produced infinitely; the area k B D l is as $\frac{1}{A\,K^{n-1}}$. Q. E. D.

Cor. 1.—If the force of attraction be inversely as the square of the distance, the force is as $\frac{B\,F}{A\,K}$.

Cor. 2.—The greater A K is taken, the nearer will this approximate to the truth.

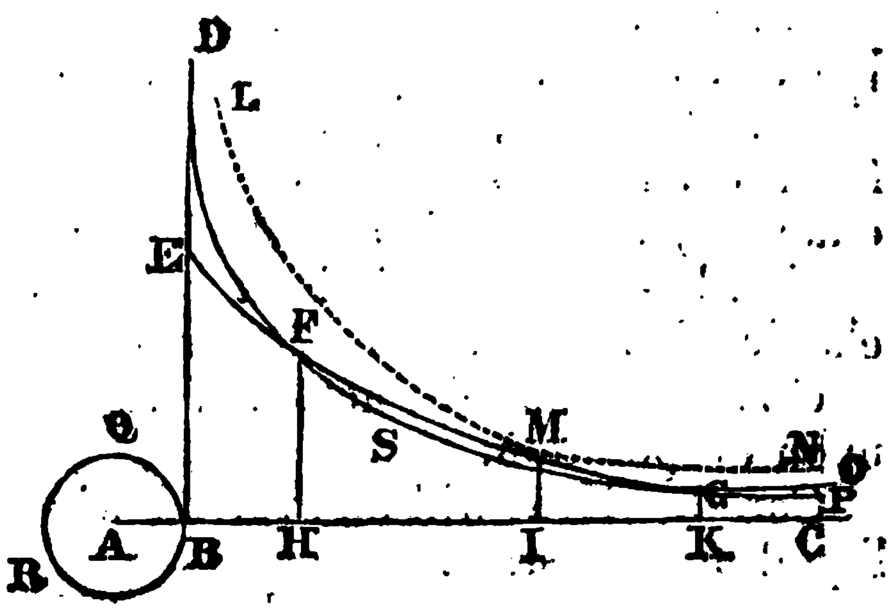
Cor. 3.—If at equal distances the forces of different particles be different, the areas B D K L at those distances will be as those forces.

Cor. 4.—If the density of the medium vary, the area B D K L will be as that density.

Cor. 5.—If different particles be placed in similarly constituted media of different densities, the areas B D K L at equal distances will be as their forces of attraction and the densities of the media.

Prop. I.

When a liquid has attained a certain temperature, its particles become mutually repulsive, and it becomes gaseous.



Let Q R B be a particle of matter, A its centre; draw the right line A C; and at B draw the tangent B D. Describe the curve E M P, such, that its ordinates F H, M I, &c. may be proportional to the force of attraction at the distances B H, B I, &c. In liquids, the force of repulsion exceeds that of attraction on the surface (Sect. 2, Prop. I). Take B D to represent the force of repulsion, and let the curve D S G O be such that its ordinates are as the forces of repulsion at the half distance of their abscissæ. Within a certain distance of B, the curve D S G O will approach the axis more rapidly than E F M, and will, therefore, intersect it in some point F (Lemma 3, Sect. 2); therefore at H, the forces will balance each other. Beyond a certain distance, the curve D S G O will approach the axis less rapidly than D F M (Sect 3, Lemma), and will, therefore, intersect it in some other point G. Increase the heat, and the points H and K will continually approach each other, until, at a certain temperature, they meet in some point I; draw the perpendicular I M, and the curve D S G O, i. e. at a higher temperature L M N is a tangent to the curve E F M P at M; hence between B and I the force

is wholly repulsive; at I evanescent; beyond I repulsive *in infinitum*. If the heat be increased by the smallest possible quantity, the particles must separate until the force of repulsion is balanced by some external force. Q. E. D.

Cor. 1.—Under the pressure of the atmosphere or any other external compression, a liquid will become gaseous at a higher temperature than in vacuo.

Cor. 2.—The greater this pressure is, the higher will be the temperature required.

Cor. 3.—Some bodies may become gaseous, without previously entering into a state of fusion; for H and K may coincide before cohesion is destroyed.

Cor. 4.—Such bodies may be fused under a strong pressure.

Cor. 5.—A liquid boils in vacuo, when H and K coincide.

Cor. 6.—Under pressure, at the point M, the boiling point is attained when the repulsive force exceeds the centripetal by a quantity equal to the compressing force.

Cor. 7.—The temperature of a boiling liquid is the same as that of the disengaged vapour.

Prop. II.

Caloric is absorbed during evaporation.

From the ratio between the specific gravities of the same body in a solid or liquid, and in a gaseous state, it is evident that in the latter, the particles are separated to a great distance from each other; therefore their calorific atmospheres are enlarged, and heat is absorbed. Q. E. D.

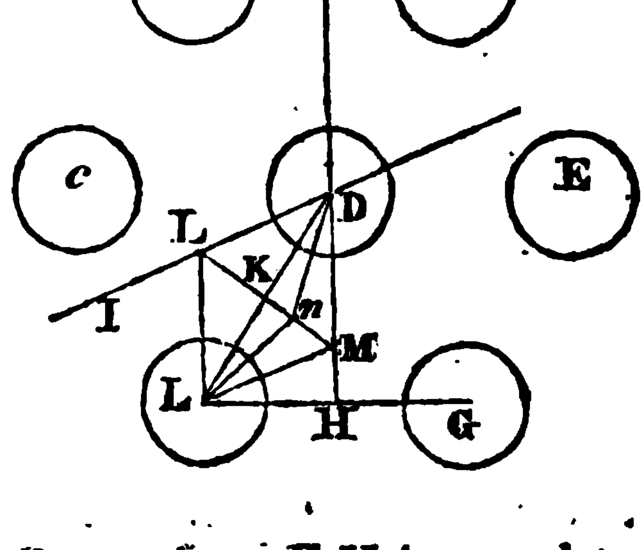
Cor. 1.—The specific heat of any body is greater when it is elastic, than when in a solid or liquid state.

Cor. 2.—Hence the action of frigorific processes which depend upon evaporation.

Cor. 3.—Heat will be evolved when a gas is resolved into a liquid or solid state.

Prop. III.

At a given temperature, the elastic force of a gas will be nearly inversely as its volume.



By Lemma 1, Sect. 3, the elastic force of a particle of a gas is inversely as the distance from its surface; therefore, neglecting the force with which the particles attract each other, the elastic force of a gas will be inversely as its volume; for let A, B, C, D, &c. be a number of particles of a gas, they are equal and at all equal distances, their forces are equal, by the hypothesis. Bisect the distance F G in H, and join D H; then, since F H is equal to

H G, the elastic force of the atmosphere of F is equal to that of G in the point H. Bisect D F in K, and through K draw L M at right angles to it, which will cut D I, D H, in L and M; join L F, F M; then, since D K, K F, are equal, the atmospheres of D and F are equally elastic at that point; because D L is equal to F L, they are equally dense at L; also at M; or if any other point *n* be taken in L M, and D *n*, F *n* be joined, the forces will be equal at that point; and if the solid figure be taken, the elastic forces of the atmospheres of D and F will be equal in every point of the hexagonal plane passing through K, to which D F is perpendicular; therefore, the entire repulsion between those particles takes place in that plane; and the same may be proved of all the other particles; therefore, since the angles L F K, K F M, are constant, as the density varies, all the lines L F, F K, L D, &c. have to each other a constant ratio; and by Sect. 3, Lemma, density at K : that at M in a constant ratio, and since the elastic force at K is inversely as K F, that at L is inversely as K F, and the same may be proved of the entire repulsive force; therefore, the entire repulsive force between the two particles D and F will be inversely as D F; therefore, by Newton's Princip. lib. 2, Prop. 23, the elastic force of the gas will be inversely as the volume. Q. E. D.

Cor. 1.—If the compression be such that the force of attraction between the particles produce any sensible effect, having given the ratio of the forces at any given distance, the force will be as $\frac{1}{D} - \frac{1}{D^2}$, each term being multiplied by the force at that given distance.

Cor. 2.—If the gas be highly compressed, its elastic force will increase in a higher inverse ratio than that of its volume.

Scholium.

If the force of attraction vary inversely as the cube of the distance, the cube of the compressing force will be as the fourth power of the density. If the force of attraction be as the fourth power of the distance inversely, the cube of the compressing force will be as the fifth power of the density.

PROP. IV.

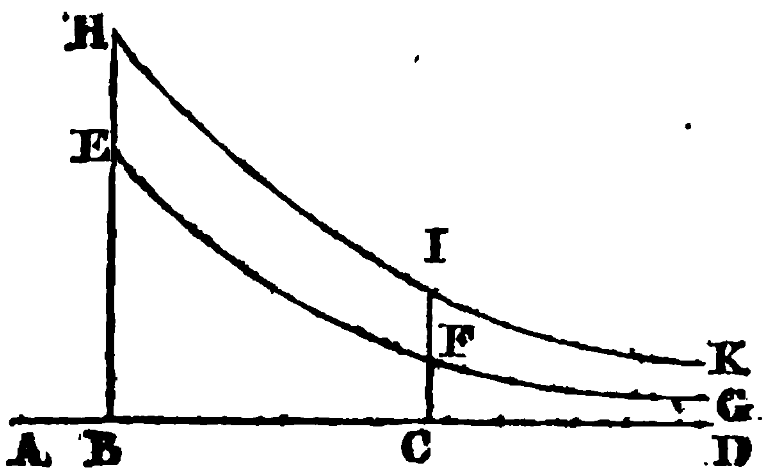
Gases will be expanded by heat, and contracted by cold, their elastic force being constant.

Let the elastic force of a confined portion of a gas be balanced by the pressure of the air; heat it, and the elastic force of the calorific atmospheres of its particles will be increased; therefore, the particles will have a tendency to separate from each other; the gas will expand; but the force of each particle is inversely as the distance; therefore, a distance will be found, such, that the gas will again be in equilibrio with the external air, and con-

sequently the expansion will proceed until this distance is attained. The converse will take place by cooling. Q. E. D.

Prop. V.

The elastic force being constant, the change, produced in equal volumes of different gases by the same variation of temperature, will be equal.



Let A D be the radius of a particle of a gas produced; let E F G be the curve whose ordinates represent the force of attraction at the distances of their respective abscissæ; these multiplied into the density of the surrounding caloric give the density of the caloric at those points; therefore the pressure at B is as the area E F G D B. Let the density of the surrounding caloric be increased, and be to its former density as $n : 1$; represent this by the curve H I K; then the area B E G D : area B H K D :: 1 : n and area B H K D : area C I K D :: A C : A B; therefore, the area B E G D : area C I K D :: A C : n A B.

Let the area B E G D be equal to the area C I K D; then A C $= n$. A B or A C : A B :: n : 1; or the distance between the particles will be as the change of temperature, force of attraction being neglected. Q. E. D.

Cor.—If D be the density of caloric, or true temperature from zero, the volume of a gas will be as D^3, when the particles are so distant that the compression of the caloric bears an insensible ratio to its whole density.

Scholium.

Hence may be established a remarkable difference between gases and vapours; in the former great elastic force remains at a temperature at which the latter become liquid or solid; therefore in gases the deviation from the laws of expansion will be much less than in vapours; in the latter, there will be variations, hereafter to be investigated, which will be the greatest in the least volatile matters.

Prop. VI.

Heat will be evolved by the sudden compression of a gas or vapour; for by compression the calorific atmospheres of the particles are diminished; therefore, part of the heat which was latent becomes sensible. Q. E. D.

Cor.—Cold results from the sudden rarefaction of gaseous matter.

Prop. VII.

Gases are attracted by solids or liquids, whether they do or do not exert on them any chemical action.

From the nature of attraction, the particles of a gas when indefinitely near the surface of solid or liquid matter, will tend to it; therefore upon the surface of every substance which is surrounded by any gas or vapour, there will be an atmosphere of that gas or vapour, of very small extent, whose density is greater than that of the surrounding medium, whose increased elastic force is balanced by that of the surrounding medium, and its tendency to the body. Q. E. D.

Cor. 1.—Hence bodies which are filled with minute pores will absorb large quantities of gaseous matter.

Cor. 2.—Hence liquids will contain air for which they may have no chemical attraction.

Cor. 3.—The rays of light will be refracted and dispersed by passing near the surface of any solid; this will be distinct from inflection.

Cor. 4.—When a dry porous body, freed from air, is brought into any gas or vapour, its temperature will be increased.

Cor. 5.—All bodies may be more or less perfectly freed from air by being heated, or placed under an exhausted receiver.

Scholium.

Prop. 6 and 7 explain some curious phenomena. Charcoal and other very dry porous substances absorb a large quantity of any gas or vapour in which they are immersed, the volume of gas absorbed being many times greater than that of the solid; hence very dry impalpable powders cannot be readily mixed with liquids. Hence also during the absorption of a gas by a porous solid, heat will be evolved, and upon this principle, the common pyrophorus seems to act.

General Remarks upon Chemical Attraction.

Chemical attraction is distinguished from that which produces mere mechanical effects, by many remarkable differences in the properties of the resulting compounds.

Introduce an inflamed stream of hydrogen into a vessel of oxygen gas; both gases will rapidly be condensed, and the only product will be water. In this experiment, the gases enter into chemical union, i. e. into that state of combination in which the attraction subsisting between the particles of the oxygen and hydrogen gases, overcomes their elastic force, and is greater than the force exerted by like particles upon each other; hence the water may be congealed, reduced to a state of vapour, or enter into many combinations, without any decomposition taking place. The sensible qualities of the gases are totally

changed; oxygen gas is a powerful supporter of combustion; hydrogen gas is highly inflammable; their compound is equally destitute of either of these properties; water may be congealed, but at the lowest temperature hitherto produced, each element retains its gaseous state.

Into a vessel of carbonic acid gas introduce a stream of ammoniacal gas; the gases will ultimately disappear, and a white crystallized solid will result, which retains the properties of the ammonia in a mild form, but none of those which distinguish the acid.

If dry nitrous gas and oxygen gas be mixed in proper proportions, the volume is reduced to one half; the gases, which were invisible, assume a deep-orange colour; each was destitute of acid properties; the compound is a powerful acid.

By combination, solids sometimes become liquid or gaseous. Mix together a solid amalgam of zinc with one of bismuth; the mixture becomes fluid. Burn a piece of charcoal in a confined portion of oxygen gas; the charcoal disappears, and carbonic acid gas is produced: the charcoal, therefore, by combination assumes a gaseous state. Similarly, mix dry muriate of lime and snow at a very low temperature; they rapidly become liquid.

The colours of bodies are often changed; dissolve peroxide of iron in sulphuric acid; into one portion drop solution of prussiate of potash, an intense blue precipitate is formed; into another portion pour solution of hydrosulphuret of potash, the precipitate is black; into a third pour subcarbonate of potash, and a yellowish-red precipitate is obtained; with arsenite of potash, a dull yellow.

The forces which produce chemical changes often act with extreme violence; place a thin slice of phosphorus upon a grain or two of hyperoxymuriate of potash; give it a gentle blow with a hammer, and a most violent detonation will follow.

During combination, a change of temperature takes place. Mix four parts of dry lime with one of water; the water loses its fluidity, for the lime remains dry, and much heat is excited. Introduce phosphorus, pulverized antimony, or bismuth into chlorine gas; the gas will be absorbed, and brilliant combustion ensues; and in all cases, if the volume be reduced, heat is excited; if increased, or if solids become liquid, or liquids, gaseous, cold is produced. Again, bodies which are susceptible of chemical union, combine only in certain definite proportions; thus in water, the weight of oxygen has to that of the hydrogen a constant ratio. If bodies can combine in two, three, or more different proportions, the ratio of the quantities of one of the elements to a given weight of the other will be as the numbers, 1, 2, 3, &c. The force of chemical attraction is not the same in all bodies of the same class, as is manifest from the various cases of simple and compound decomposition. These, and all other chemical changes

are the result of the operation of the two great powers, attraction and the repulsive force of caloric. In the present state of chemical science, from the want of some important data, we cannot estimate the effect of these forces, nor compare the relative forces of chemical attraction, which is very different to the order of decomposition; for it is affected and even inverted by the following causes, the results of the operation of the primary forces upon similar particles.

1. *Temperature.*—Heat mercury to nearly its boiling point during several days, giving it access of air; it will be converted into a red oxide; heat this nearly to ignition, the mercury reassumes its metallic state, and oxygen gas is evolved. At the usual temperature of the air, the attraction of the particles of mercury for each other, and the elasticity of the oxygen gas, prevent their union: at a certain temperature, the former force is so far diminished, that they combine: at a temperature approaching to ignition, the mercury becomes elastic, and the elasticity of the oxygen is amazingly increased, and they are again separated: similarly, at the ordinary temperature of the air, sulphuric or muriatic acid will separate the boracic from its combination with alkaline or earthy bases; the contrary takes place at a red heat, evidently because the sulphuric and muriatic acids, from their tendency to become elastic, are united to the bases by a less force than at a lower temperature. Many other cases might be advanced to prove that the apparent attractions of bodies for each other are changed by variations of temperature, which acts in two ways; first, when it favours chemical union, it diminishes the cohesive force of one or more substances; secondly, when it effects decomposition, it is by giving to one element at least a tendency to become elastic. Hence tables of chemical attraction serve for only one temperature.

2. *Elasticity.*—This might have been considered solely as a result of the last cause, but it acts in various peculiar ways at the ordinary temperature, and on this account deserves a separate place. Carbonic acid is elastic at all temperatures, and probably has a greater tendency to a gaseous state than any other. Its power of saturation is very great, and the force with which it adheres to many bases is peculiarly powerful, yet it is separated from its combinations by every other acid, doubtless, in part at least, from its great tendency to the elastic state at all temperatures. And, in general, bodies which are volatile are separated from their compounds more easily than those which are fixed. Hence carbonic acid will not unite with dry lime, but with its hydrate; and phosphorous will not shine in pure oxygen gas.

3. *Cohesion* promotes combination when the body to be formed has a great cohesive force, and those to be separated are elastic, fluid or soluble, in the menstruum employed. It opposes it when the substance used for decomposition has a cohesive

force greater than the other assisting forces. For example, in solution, potash and soda separate all the metallic oxides from most acids, because, by reason of cohesion, the oxides are insoluble. Barytes separates potash and soda from most of their salts, and nearly all the resulting compounds of barytes are insoluble. Lime separates them from those acids with which it forms insoluble compounds, but in no other cases. Although the force does not become actual cohesion, until the compound is formed, we here see the operation of the force which ultimately produces cohesion, while the particles are yet separated. These remarks need not be further extended, since they are obvious to every reader.

Electricity appears to be most intimately connected with this subject. In all cases of electrical excitation, the opposite states are always exhibited in such proportion as will mutually neutralize each other, whether excited in the ordinary manner, or by chemical agency, as in the galvanic series. If compound bodies, as neutral salts, be exposed to the operation of the galvanic battery, the principles are separated from each other; oxygen, chlorine, and acids appear at the positive pole, while hydrogen, azote, and inflammable matter, together with earths, alkalies, and metallic oxides, tend to the negative; and those bodies which unite with the greatest force differ most in their natural electric energy. Electricity is excited by the contact of dissimilar bodies, when the same relation is observed, with this peculiar difference, that bodies of the same class have different degrees of electric energy, whereby, after contact, the two electricities are exhibited. Whether electricity be the cause of chemical combination or a counteracting force, cannot yet be determined; and for the purposes of research, it is not material that this should be decided. However, until the several electric energies of bodies be determined, as well as the relation of the electric energy to caloric, to the atomic weight, specific gravity, &c. nothing can be determined with certainty. I therefore withhold further researches into the nature, &c. of chemical combination for the present, except that all tables of capacities of bodies for heat, expansion, &c. should be computed for weights proportional to the atomic weights, for then they represent the capacities, &c. of single atoms; this is most conspicuous in cases of combustion. Since heat is evolved during that process, there must be a diminution of capacity; if, therefore, we add the atomic capacities of the bodies, and from the sum subtract the atomic capacity of the product (that is, the capacity of a weight of the product, equal to the sum of the weights of the ingredients consumed), the remainder will be the proportion of the diminution of capacity, or of the heat evolved; for example, the atomic capacity of hydrogen gas is 2·82; that of oxygen is 4·75; the sum is 7·57; the capacity of an atom of aqueous vapour is 1·75; therefore, 5·82 is the heat evolved.

Similarly, the atomic capacity of carbon is 1·95; twice the atomic capacity of oxygen is 9·5; the sum 9·695; the atomic capacity of carbonic acid is 2·887; i. e. 6·808 is the quantity of caloric evolved. Until we are furnished with the above data, and particularly with the precise relation of electricity to chemical attraction and caloric, it will be vain to attempt to institute any researches into the principles of chemical philosophy; and, in all computations, tables must be constructed for the atomic weights of bodies in every case. For the table of atomic capacities, the argument is, atomic weight × capacities of equal weights.

Heat evolved by combustion or combination: argument, sum of the atomic capacities of the bodies combined — atomic capacity of the compound.

Atomic expansion in volume: argument, $\frac{\text{atomic weight}}{\text{specific gravity}}$; in length, the cube root of the above quantity.

Conducting powers: argument, $\sqrt[3]{\left\{\frac{\text{atomic weight}}{\text{specific gravity}}\right\}}$ for the lengths of the metallic rods on which the experiment is to be made, in order to obtain the true ratio of the conducting powers.

Article III.

Abstract of a Memoir entitled "An Attempt to ascertain the Chemical Composition of those Minerals which possess the same Crystalline Form as Pyroxene." By H. Rose.

(*Concluded from* p. 231.)

4. *Pyroxenes, with Lime and Protoxide of Manganese as Bases.*

The red silicate of manganese from Langbanshyttan, in Wermeland, Sweden.

This mineral (manganèse oxidé silicifère rouge de M. Haüy) occurs generally only massive on the Hartz, Siberia, Transylvania, and near Langbanshyttan, with a distinct foliated texture identical with pyroxene, which is further proved by an analysis of Prof. Berzelius, according to whom it is a bisilicate of protoxide of manganese combined with some bisilicate of lime.

The result of his analysis was:

Silica.	48·00	containing oxygen 23·80
Protoxide of manganese	49·04	10·76
Lime	3·12	0·87
Magnesia	0·22	
Oxide of iron	Trace	
	100·38	

It is, therefore, a bisilicate of protoxide of manganese combined with a small quantity of bisilicate of lime.

Besides the pyroxenes of these four divisions, there exist in nature also some which contain alumina as a real constituent part. They are rare, and the quantity of alumina which occurs in them never amounts to more than seven per cent. The alumina, which contains three atoms of oxygen, is not isomorphous with the bases containing two atoms of oxygen, and its presence in the pyroxenes is still enigmatical. It seems that in proportion as the quantity of alumina increases, that of the silica decreases, so that it is not improbable that it does not exist as a silicate in the pyroxenes, but as an aluminate, of which the electronegative constituent part may be isomorphous with silica. Such pyroxenes which contain alumina are the black pyroxene from Frascati analysed by Klaproth;* the pyroxene from Ætna analysed by Vauquelin, and the black pyroxene from Pargas analysed by Nordenskiold.

The greater part of the pyroxenes analysed by M. Rose were fragments taken from massive pieces, with a very distinct foliated fracture. In this state, the minerals contain less foreign admixtures than when they are crystallized. In this case, the crystals are generally large, and have distinct faces; but between the laminæ very distinct admixtures may be discovered, and so many traces of the matrix that they may be seen with the unassisted eye. In the beautifully crystallized pyroxene from Frascati, the naked eye discovers many such foreign admixtures, while even with a glass none can be found in the massive white malacolite from Orrijervi.

The pyroxenes analysed by M. Rose were all measured by Prof. Mitscherlich, and found to be real pyroxenes. The inclinations of the two sides, and of the terminal face, approached to the numbers given by Haüy, and agreed completely with the measurement of Phillips. These cleavages occurred on the malacolite from Orrijervi, the yellow variety from Langbanshyttan, though they were not so clear in the hedenbergite, in both malacolites from Bjormyreooeden, or the hard sahlite.

The pyroxene from Taberg is the only one of those analysed by M. Rose, which is well crystallized. The red silicate of manganese from Langbanshyttan shows only the cleavage parallel to the sides, and the truncations of the acute and obtuse solid angles. The inclination of the sides is the same as that mentioned by Haüy as belonging to

* Klaproth found alumina in all pyroxenes, of which he has published an account in the collection of his analyses; however, among them all, the pyroxene from Frascati only is a real pyroxene; the augit from the Sanalpe is hornblende; the slaggy augit from Sicilia which is not crystallized is, according to Prof. Weiss, an obsidian; the common augits from the Rhon mountains are not crystallized, and no trace of foliated fracture can be discerned in them.

pyroxene. The cleavage is very indistinct in the soft sahlites which contain serpentine. Their external similarity only with the hard sahlite, from Sahla, was the reason which induced M. Rose to analyse them. It was necessary to repeat this analysis often as it gave questionable results, until at last no doubt could remain about their true chemical nature. The cleavages parallel to the sides of the prisms and its truncations only were observable, and very indistinct; the terminal face could not at all be discerned. This imperfect crystalline structure depended evidently upon the foreign admixture of serpentine.

Article IV.

Some Experiments and Researches on the Saline Contents of Sea-water, undertaken with a View to correct and improve its Chemical Analysis. By Alexander Marcet, MD. FRS. Honorary Professor of Chemistry at Geneva.*

In a paper on the temperature and saltness of various seas, which the Royal Society did me the honour to publish in their Transactions for the year 1819, I threw out a conjecture, that the sea might contain minute quantities of every substance in nature, which is soluble in water. For the ocean having communication with every part of the earth through the rivers, all of which ultimately pour their waters into it; and soluble substances, even such as are theoretically incompatible with each other, being almost in every instance capable of co-existing in solution, provided the quantities be very minute, I could see no reason why the ocean should not be a general receptacle of all bodies which can be held in solution. And although it will appear from the following account, that I have been unsuccessful in some of my attempts to prove the truth of this conjecture, it may fairly be ascribed either to a want of sufficient accuracy in our present methods of chemical analysis, or of the requisite degree of skill in the operator.

Some time after the communication to which I have just referred, an extraordinary statement was pointed out to me, upon the authority of Rouelle, a French chemist of the last century, from which it appeared that mercury was contained in sea salt;† and I saw soon after in the Annales du Musée, vol. vii. a paper by the celebrated chemist Proust, who, in a great measure,

* From the Philosophical Transactions for 1822. Part II.
† See Journal de Médecine, vol. xlviii. 1777, page 322.

confirmed that statement, by announcing that he had found traces of mercury in all the specimens of marine acid which he had examined.

Improbable as the fact appeared, I thought it worth while to repeat the experiment, and to take that opportunity of making some collateral researches upon other substances, much more likely than mercury to be discovered in sea water.

For this purpose I availed myself of the kindness of my friend Mr. John Barry,* who happened to be in the vicinity of Portsmouth, to supply me with specimens of sea-water, carefully concentrated upon the spot, in vessels of Wedgwood ware, and with scrupulous attention to cleanliness in the process. Accordingly he was so obliging, as not only to send me a quantity of brine evaporated under his own eye, in the manner just mentioned, but he also collected for me a valuable series of specimens from the salt works near Portsmouth, from all the stages of the process, so as to afford me an opportunity of investigating with accuracy all the chemical circumstances of this interesting branch of national economy. Finding myself, however, much pressed by time at this late period of the session, I shall, after briefly adverting to Rouelle's supposed discovery, confine myself in this communication to a few observations which I have made on sea-water itself; keeping out of view, for the present, the topic of salt-making, which, however, I intend to resume at some future period, in a more complete and satisfactory manner.

I first attempted to detect mercury in a specimen of *bay-salt*, such as is obtained in the salt-works near Portsmouth, by spontaneous evaporation. This variety of salt forms large crystals, but is always more or less contaminated by earthy matter, which gives it a dirty appearance. It has, probably, a general resemblance to the French Sel de Gabelle, which is more impure still, though, I believe, obtained in a similar manner.†

Eight ounces of this salt were put into a coated retort connected with a receiver, and about four ounces of nitrous acid were poured upon it. A pretty brisk action took place, which was further increased by the application of heat; fumes of chlorine were immediately disengaged, and a reddish fluid condensed in the receiver; the heat was continued, and gradually raised in a charcoal fire till no acid or moisture any longer came over; at which time a new emission of red fumes indicated that the nitrate formed in the retort was beginning to part with its acid: minute drops of fused salt soon bedewed the upper part and neck of the retort, so as to be mistaken at first for a sublimate. This, however, proved to be almost solely muriate of soda; and

* Mr. John Barry, of Plough Court, inventor of a new and valuable process for preparing extracts in vacuo, &c.

† The name of *bay-salt* is often applied to foreign as well as British salt, and in general it simply denotes that the salt has been obtained by spontaneous evaporation.

on careful examination, it did not appear to contain the smallest atom of corrosive sublimate.

I next dissolved five or six pounds of bay-salt in water, and collected in a filter the insoluble earthy sediment, in which Rouelle stated that the quicksilver was usually found. This sediment being carefully dried, and heated to redness in a coated retort, a white sublimate arose, and condensed on the neck of the retort; but this sublimate proved to be muriate of ammonia, and did not contain the smallest portion of corrosive sublimate, or other mercurial salt. This sal-ammoniac, though evidently formed during the distillation from the vegetable and animal matter contained in the sediment, suggested to me the idea of looking for ammonia amongst the contents of sea-water.

I now submitted some Sel de Gabelle, which I had procured from Calais for the purpose, to similar experiments, and the sediment, also, was carefully examined. The result was essentially the same as with the bay-salt. After adding nitric acid to the salt, the heat was gradually pushed to redness; and when all the moisture was evaporated, a white sublimate appeared, as in the former case, which, in this instance, proved to consist almost entirely of nitrate of soda; but always without the least particle of mercurial salt, and without any muriate of ammonia.*

I therefore think myself justified in concluding that the mercury, which other chemists have detected in sea-salt or its products, must have been introduced there from some local or accidental circumstances.

In experiments upon sea-salt, or in general upon the saline contents of the sea, it is obvious that, in order to exclude sources of error, it is necessary to operate upon pure sea-water, and not upon salts obtained from it by the usual processes in the large way, these being always more or less contaminated by the clay pits in which the evaporation is carried on, by the metallic boilers, or other adventitious causes. I, therefore, now turned my attention to the sea-water itself, and in particular, the perfectly pure and transparent specimen of concentrated brine from the Channel, which I have above mentioned. Mr. Barry procured this water near Bembridge floating light, about two miles north-east of the eastern extremity of the Isle of Wight, and the evaporation which it had undergone at Portsmouth, had only separated from it a quantity of calcareous matter, principally selenite.†

* In the former experiment the sublimate was principally muriate of soda, owing, no doubt, to the decomposition having been less complete, and the operation less gradually conducted than in the latter experiment.

† The water, immediately on being raised from the sea, had been allowed to stand a sufficient time to deposit the earthy particles suspended in it, by which means it had become beautifully transparent: 100 pounds of the water produced only three grains of earthy sediment, in which I could discover nothing but carbonate of lime and oxide of iron. It is in this sediment, according to Rouelle, that mercury is to be found. I need hardly say that I could not detect in it the least particle of that metal.

A few pounds of this water were evaporated nearly to dryness, at a gentle heat, so as to reduce the mother liquor to the smallest possible quantity. This liquor was suffered to drain off, and reserved for experiments, as it is in this fluid that any new ingredients are most likely to be detected.

I had suspected that some nitric salt might be found in sea-water, but in this I was disappointed. The discrimination by the shape of the crystals being in this instance scarcely practicable, the mode which I employed for detecting it, consisted in concentrating the bittern in a glass tube or retort, till it began to deposit solid matter, then adding sulphuric acid and gold-leaf, and boiling the mixture; the gold-leaf was not in the least acted upon, nor was any smell of nitric acid perceived; but on adding the smallest quantity of nitre to the same mixture, the gold was dissolved, and the smell of aqua regia was instantly perceived.*

A portion of the said bittern was next examined by appropriate reagents, with a view to detect any minute quantity of earths or metals, especially alumina, silica, iron, and copper, which former inquirers might have overlooked; but I could find no other earth except magnesia: and to my surprise, I did not find in the bittern the least particle of lime; which proves that sea-water contains no muriate of lime, as had been generally supposed. I was equally unsuccessful in my attempts to detect iron or copper, by the most delicate tests. In fact, neither alkalies nor alkaline carbonates precipitated any other substance from the bittern of sea-water, except magnesia.

The deposit obtained at Portsmouth during the early period of the concentration of the water, being analyzed, I found it to consist of selenite, mixed with a little muriate of soda, and a portion of carbonate of lime. The presence of this last substance in sea-water, in a state of perfect solution, being, I believe, a new fact, I neglected no means of establishing it with certainty, an object which was accomplished without difficulty.†

Carbonate of magnesia having been supposed by some chemists to exist in sea-water, I looked for it in the same deposit; but I could not detect the least portion of it by the most delicate tests.‡

I next turned my attention to the alkaline salts of sea-water; and here I was more fortunate; as I succeeded in ascertaining beyond a doubt, that sea-water contains ammonia, as it yielded sal ammoniac by evaporation and sublimation. This result was easily obtained. Some of the bittern being evaporated to dryness in a retort, and a low red heat applied, a white sublimate

* For this easy and elegant process for detecting nitric acid, a point attended with difficulty, I am indebted to Dr. Wollaston.

† The deposit was treated with acetic acid, which occasioned an effervescence. The clear liquor being then decanted off, and evaporated to dryness, and alcohol added, acetate of lime was found in the filtered alcoholic liquor.

‡ Namely, solution of the mass in dilute muriatic acid; precipitation of the lime, and addition of phosphate of ammonia to the filtered liquor.

appeared in the neck of the retort, which proved to be muriate of ammonia. The mode in which this substance was identified was as follows:

1. The sublimate was re-dissolved in water, re-evaporated to dryness, and again sublimed by the heat of a spirit lamp.

2. This new sublimate being again dissolved, and solution of magnesia and phosphoric acid added, a triple phosphate was formed.

3. On adding caustic potash to the solution, and bringing the mouth of a phial containing muriatic acid close to the vessel, abundant white fumes appeared.

4. The sublimate gave precipitates both with muriate of plátina and nitrate of silver.*

Sulphate of soda having been mentioned by many chemists as one of the constituents of sea-water, I endeavoured to ascertain, whether or not it existed in it. But all attempts to detect this salt in the bittern by crystallization were fruitless, though great pains were taken for that purpose; and I feel the more confident that there is no sulphate of soda in sea-water, as the presence of this salt in any but the most minute quantities would be quite incompatible with our knowledge of chemical affinities. For since there are co-existing in sea-water muriate of soda and sulphate of magnesia, it is evident that sulphate of soda would decompose muriate of magnesia, which salt is known to be in sea-water. And again we know, that sea-water contains sulphate of lime and muriate of soda; therefore it cannot contain sulphate of soda; for in that case we should have muriate of lime, which I have shown to be contrary to fact.

The last circumstance which I shall at present notice relates to the state in which potash exists in sea-water.† Potash is found, by its appropriate re-agents, principally in the bittern, but it is found also among the salts which are separated from it, especially in the latter period of crystallization. By further and repeated evaporation of the bittern, and successive separation of the mother water remaining after the removal of the crystals formed, various distinct crystals were obtained possessing their characteristic form; namely, prismatic sulphate of magnesia, cubic and star-shaped muriate of soda, and rhombic crystals, quite different from either of the other salts. These crystals, which were evidently portions of an oblique rhombic prism, being carefully separated and washed with water and alcohol,

* As it did not enter into my plan, on this occasion, to turn my attention to the estimation of proportions or precise quantities, I have not attempted to estimate exactly the proportion which ammonia bears to the other ingredients of sea-water; but as its presence can easily be shown in 100 grains of the bitter salts, its quantity cannot be extremely minute.

† It will be recollected that the presence of potash in sea-water, though announced by myself in the paper on sea-water to which I have before alluded, was Dr. Wollaston's discovery. I have likewise to mention, that the above experiments respecting the state in which it exists, were either made by him or at his suggestion.

proved to be a triple salt of sulphate of potash and magnesia; a salt so easily analysed, that it would be quite superfluous to relate the particulars of the process.

It now remained to be ascertained, whether potash might not also exist in sea-water in the state of muriate of potash, or of triple muriate of potash and magnesia. That a considerable quantity of potash remains in the bittern, even after the separation of the triple sulphate, is easily ascertained; and by careful evaporation it may be made to crystallize as a triple salt in rhombic crystals; but the constitution of this salt is so delicate, that it is liable to be separated into muriate of potash and muriate of magnesia by water alone; and it is with certainty decomposed by alcohol, which takes up the magnesian muriate, and leaves the other undissolved.

From the foregoing observations and experiments it may, therefore, be inferred,

1. That there is no mercury, or mercurial salt, in the waters of the ocean.
2. That sea-water contains no nitrates.
3. That it contains sal ammoniac.
4. That it holds carbonate of lime in solution.
5. That it contains no muriate of lime.
6. That it contains a triple sulphate of magnesia and potash.

Some of these circumstances will, of course, require that former analyses of sea-water, and my own in particular, should be corrected and revised; but this I shall not attempt to do, until I have obtained further, and still more precise information on the subject.

Article V.

Astronomical Observations, 1823.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Feb. 24.	Emersion of Jupiter's second satellite.	6h 29′ 19″ Mean Time at Bushey. 6 30 40 Mean Time at Greenwich.

Article VI.

Meteorological Results deduced from diurnal Observations kept at the Apartments of the Royal Geological Society of Cornwall, Penzance, for 1822. By E. C. Giddy, Curator. (Communicated by Davies Gilbert, Esq. MP. FRS. President.)

1822.	Barometer.												
	Maximum.	Minimum.	Mean of the maximum.	Mean of the minimum.	Mean of the month.	Monthly range.	Mean daily range.	Greatest daily range.	True maximum.	True minimum.	Mean of true maximum.	Mean of true minimum.	True mean of the month.
January ...	30·26	29·10	30·05	29·96	30·005	01·16	00·10	00·50	30·212	29·058	29·990	29·903	29·951
February ...	30·48	29·10	29·94	29·84	29·890	01·38	00·10	00·57	30·444	29·034	29·880	29·774	29·827
March.	30·30	29·52	30·00	29·86	29·930	00·78	00·10	00·34	30·224	29·454	29·931	29·707	29·864
April......	30·24	29·00	29·77	29·70	29·735	01·24	00·07	00·30	30·186	28·916	29·707	29·631	29·669
May	30·12	29·24	29·81	29·73	29·770	00·88	00·06	00·28	30·084	29·160	29·726	29·646	29·686
June	30·04	29·52	29·90	29·85	29·875	00·52	00·04	00·14	29·949	29·412	29·795	29·742	29·768
July	30·08	29·20	29·66	29·59	29·625	00·88	00·06	00·26	29·978	29·104	29·594	29·521	29·557
August	30·06	29·30	29·77	29·73	29·750	00·76	00·04	00·20	29·952	29·304	29·658	29·628	29·643
September..	30·02	29·14	29·77	29·73	29·750	00·88	00·04	00·26	29·945	29·056	29·680	29·640	29·660
October....	29·90	28·94	29·49	29·37	29·430	00·96	00·11	00·40	29·828	28·862	29·413	29·295	29·355
November..	30·10	29·08	29·61	29·52	29·565	01·02	00·09	00·36	30·028	29·020	29·344	29·454	29·499
December..	30·22	28·88	29·67	29·80	29·835	01·34	00·07	00·30	30·172	28·886	29·926	29·759	29·793
Annual Means, &c.	30·48	28·88	29·80	29·72	29·760	11·60	00·07	00·57	30·414	28·886	29·750	29·649	29·694
Ditto 1821	30·50	27·85	29·72	29·64	29·680	13·14	00·06	00·59	30·434	27·806	29·654	29·569	29·611

Barometer, 1822.—Highest, Feb. 27, Wind NE, 30·48; Lowest, Dec. 2, Wind W, 28·88.

1822.	Day and Night Thermometer.								Common Thermometer.									
	Maximum.	Minimum.	Mean of the maximum.	Mean of the minimum.	Mean of the month.	Monthly range.	Mean daily range.	Greatest daily range.	Minimum at 8 a. m.	Maximum at 2 p. m.	Minimum at 8 p. m.	Mean at 8 a. m.	Mean at 2 p. m.	Mean at 8 p. m.	Mean of the month from the three preceding columns.	Monthly range.	Mean daily range.	Greatest daily range.
January ...	51	34	47	42	445	17	6	9	37	50	36	44	46	44	442	14	3	7
February...	54	36	49	42	455	18	7	12	38	53	39	44	49	45	460	15	5	10
March.....	58	39	54	45	495	19	9	14	44	56	43	48	52	48	491	13	5	8
April	65	36	53	43	480	29	11	17	40	64	40	48	52	47	490	24	6	10
May	69	42	62	49	555	27	13	19	43	69	46	55	61	55	570	26	7	12
June	78	52	70	58	640	26	12	21	58	76	55	63	69	63	650	21	7	11
July	71	52	67	56	615	19	11	15	56	71	56	61	65	61	621	15	5	11
August....	77	48	67	55	610	29	12	18	54	76	54	60	66	60	620	22	6	12
September..	68	45	63	55	590	23	10	15	47	68	50	56	62	57	581	21	5	10
October....	63	43	57	50	535	20	8	13	47	62	48	53	56	54	541	15	4	8
November..	58	39	54	46	500	19	7	14	42	58	40	48	53	51	502	18	4	9
December..	54	28	44	37	405	26	7	18	28	53	32	40	44	40	411	25	6	12
Annual Means, &c.	78	28	57	48	525	228	9	21	28	76	32	51	56	52	536	191	5	12
Ditto 1821	73	26	56	48	520	223	9	18	26	71	20	52	56	52	535	166	5	12

Day and Night Thermometer.—Highest, June 6, Wind SE, 78°; Lowest, Dec. 21, Wind E, 28°.
Common Thermometer.—Highest, June 6 and Aug. 22, Calm, 76°; Lowest, Dec. 21, Wind E, 28°.

1822.	Wind and Weather.														Rain in Inches.			
															On the top of the Geological Museum, No. 1.			Ground level, No. 2.
	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Calm.	Brisk.	Boisterous.	Prevailing.	Rainy and showery days.	Dry days.	8 a. m.	8 p. m.	Total.	
January ...	3	5	1	0	2	3	5	12	0	3	0	NW	16	15	0·995	0·460	1·455	2·425
February...	2	1	0	2	4	12	4	3	0	10	0	SW	11	17	0·835	0·615	1·450	2·440
March......	2	1	1	4	5	10	6	2	0	13	1	SW	14	17	0·555	0·920	1·475	2·800
April......	4	3	4	4	3	6	2	4	0	5	2	SW	10	20	1·120	0·205	1·325	2·380
May......	3	3	5	7	6	2	2	0	3	1	0	SE	9	22	1·055	0·040	1·095	1·340
June......	3	0	2	6	5	5	3	3	3	2	0	SE	10	20	0·955	0·955	1·910	2·240
July......	2	0	1	4	3	6	6	9	0	9	0	NW	15	16	4·335	3·055	7·390	9·070
August....	3	2	0	7	1	6	9	2	1	2	0	W	9	22	0·910	0·690	1·600	2·200
September .	2	2	6	8	1	7	2	2	0	7	2	SE	10	20	0·815	0·675	1·490	1·865
October....	3	0	0	8	6	5	7	1	1	15	7	SE	24	7	1·845	1·560	3·405	5·315
November..	1	1	0	1	6	11	2	1	0	14	2	SW	22	8	1·500	2·230	3·730	7·255
December..	1	6	8	5	1	4	3	3	0	6	0	E	8	23	0·695	0·535	1·170	2·545
Annual Results.	29	24	28	56	43	77	58	42	8	87	14	SW	158	207	15·555	11·940	27·495	41·875
Ditto 1821	20	16	21	59	42	75	65	56	5	180	28	SW	185	180	21·160	11·350	32·510	43·590

No. 1, 45 feet above the surface of the ground, and 143 above the level of the sea. No. 2, 90 feet above the level of the sea.

The result of very attentive observations on the rain guage throughout this year tends to confirm the conjectures offered in the number of the *Annals of Philosophy* for July last, p. 18.

The excess of rain received by the guage on the ground level is, as before, very great at particular times, and, on the whole, nearly corresponding with that of the last year, viz.

$$\left.\begin{array}{l}\text{1821 was as 1 to 1·512}\\ \text{1822 was as 1 to 1·523}\end{array}\right\}\text{or as 2 to 3 nearly.}$$

Among the daily differences, we found as much as 1·5 excess; and, on the other hand, in quantities very nearly equally. The least monthly excess was that of June, being ·172 only, and the greatest monthly excess that of December, which rose to 1·175. In every instance, the excess of the lower above the upper guage has been proportioned to the more or less velocity of the wind; and nothing has occurred to weaken, but much to corroborate, the idea, that it is principally, if not altogether, occasioned by the whirl or eddy produced by the recoil of the current of air from the sides of the building. This is a question of fact, which we continue to hope some of your meteorological correspondents, better provided with anemometers, will try by the test of actual experiments.

Penzance, Feb. 14, 1823.

Article VII.

On the unconformable Position of the Pontefract Rock of Sandstone, with respect to the subjacent Coal-measures, as shown in the new Geological Map of Yorkshire; and regarding some Errors therein, as to Parts of the Ranges of certain Rocks in the Coal Series. By Mr. John Farey.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Howland-street, Feb.* 19, 1823.

I am one of those who have felt a strong interest in the perusal of several long and very important geological papers, chiefly from the pens of Messrs. Weaver, Conybeare, Buckland, Phillips, Sedgwick, and Winch, which have appeared in your last four volumes; and observing that Mr. Conybeare, in p. 137 of your last number, considers the continental Rock, which has of late been much the subject of discussion, under the name of *rotheliegende*, to be probably the same with the English rock, which my friend Mr. Smith has named the "Pontefract Rock," and lately depicted its course in his four-sheet Geological Map of Yorkshire, sold by Cary: I beg permission to state in your *Annals*, that I fully concur with Mr. Conybeare in opinion, that

the rock in question belongs to, and is the lowest of, the unconformable, magnesian, and gypseous series,* which locally covers and forms the eastern boundary of the Yorkshire coal-field, and that this Pontefract rock has been improperly associated and linked with the six other coal-measure grit rocks, named by Mr. Smith on the margin of his map. I agree also with Mr. C. in thinking, that this Pontefract rock deserves a very careful examination and description. Towards the accomplishment of which object, I beg to mention as the results of much labour and thought bestowed on the investigation of particular rocks, two general maxims, which I submit, should always be kept in view by the practical geologist, viz.

1. That an individual rock or stratum *is never uniform throughout* its whole extent; that is, none of them display *at every point* the same thickness, composition, or state; nor do their beds or fissures contain *everywhere* the same organic or other extraneous matters.

2. That *no unique parts occur* locally, in any rock or stratum, except, perhaps, in places where an alluvial covering may have infiltered or otherwise communicated its accidental properties; that is, whatever qualities or states, the beds of any individual rock or stratum may *in one place* exhibit, or whatever imbedded or venigenous matters it may *in one place* contain; each and every of such qualities, states, and matters (with the exception, seldom difficult to discriminate, which has been mentioned above), and the same beds and thicknesses, nearly, may be sought for, and with some confidence expected to occur, *in numerous other places*, in the whole course and extent of such individual rock or stratum.

Which maxims suggest forcibly, that much remains yet to be done, which the concurrence of numerous observers can only accomplish, before *all the properties* of any individual rock or stratum, and their relative frequency of occurrence, being known, the most *essential characters* can be selected (among which the precise *species* or varieties of *organic remains*, will mostly stand foremost, I believe), whereby to identify detached and far distant parts, of such individual rock or stratum.

In the pages referred to in the note below, I have shown, that the Pontefract rock of sandstone, often in so incoherent or loose a state as to be dug for *sand*, shows itself almost uninterruptedly at the western edge of the yellow or magnesian limestone, across the counties of Nottingham, Derby, York, Durham, and part of

* On this point, viz. as to *the immediate contact* always of the Pontefract rock with the lowest magnesian limestone rock, my falling into error in 1807, and (thanks to Mr. William James as to the Bedworth case, and to Mr. James Porter as to the Garforth case) after seven years setting myself right again, respecting *the unconformableness* of the series overlying our coal-measures, had with me no effect; as will appear in pages 157, and 462 to 465 of my first volume of "Derbyshire Report;" and pages 168, 409, 410, &c. of the third volume; also in the Philosophical Magazine, vol. xlv. pages 167, 168, 174, 342, &c.; and vol. xlvi. p. 283, &c. wherein I have correctly represented this important fact.

Northumberland; besides which, I have there mentioned the probability, that this same rock underlies the magnesian limestone in Salop and in Cumberland counties; and, perhaps, it exists also under that of Abberley, in Worcestershire; but these last very contorted rocks, and others such on the north of Dudley, at and southward of Breedon, in Leicestershire, and at Wild Park, in Derbyshire,* require, I am of opinion, a great deal more of careful investigation than has yet been bestowed upon them, before any thing satisfactory can be concluded concerning them.

Mr. Conybeare's observation in p. 137 is perfectly just, as to *the highest seams of coal*, and the strata of the regular series accompanying and overlying them, not being, perhaps, displayed on the surface, in any part of the British Islands; and it is equally true, that the parts or places are, in very few of our extensive coal-fields, yet ascertained, where *the series is the most complete*, or where the highest of their conformable carboniferous strata are visible.

In the year 1816, the late Duke of Buccleugh employed me professionally, among other matters, to ascertain this point, as to the Midlothian coal-field; the full details of which investigation remain in the hands of his Grace's intelligent mineral agent, Mr. James M'Laren,† of Dalkeith; showing, that the town of Fisher-row, near to Musselburgh, stands on *the highest stratum*, of above 5000 feet thick of coal-measures, including 84 seams of coal! ‡ as has been inferred, from a systematic comparison of 2374 spots or places of observation, in the pits, boreings, levels, and quarries, or visible bassets of the strata of that district; whence, the extremes and *the average thicknesses* of the greater part of 337 alternating strata are ascertained, amounting together to the total thickness above named.

I have frequently pointed out to my mineral friends resident

* If the Breedon and Wild Park limestones (Derb. Rep. i. 158) belong to the *lower* magnesian rock, may not the gypsum hummocks of Chellaston, Aston, and Ballington (Rep. i. 149, &c.) intermediately situated, in a strata trough, belong to the gypseous red marl, resting immediately upon that rock, answering to the gypsum near Fairburn, in Yorkshire (Phil. Mag. vol. xxxix. p. 102), which, in Bollum Farm Well, and many others thereabouts, has proved pure and crystallized, several yards thick?—and may not the absence in Derbyshire and Yorkshire, of salt springs and rock salt, which last in Cheshire, underlies gypsum, arise from the latter belonging (as locally imbedded masses) to the upper or great red marl, overlying *the very irregularly coarse gritstone*, which, on Sherwood Forest and in other situations, I mistakenly represented as "gravel rock," in most of my early writings? The Birchwood Park, and the Newbold Astbury limestones, occurring in small denudations, from whence *no basset edges could be traced*, were, in 1811, hesitatingly referred by me to the yellow limestone series (Derb. Rep. i. 409 and 461), when, but for a complete error, as to "an upper series of coals above the yellow limestone" (see my Index), of which I had often been told, I should have associated them, either with the shale *limestone*, or with the first limestone rock.

† And other copies in my possession. I am happy in this opportunity to mention, that Mr. M'Laren is now carrying into effect the instructions which he received from me, by making similar surveys of the districts in which his Grace's other mineral properties are situated.

‡ See Mr. Westgarth Forster's Treatise on a Section of Strata, p. 89, 2d. Edit.

in Yorkshire, that near to the edge of the yellow limestone, about south-east from Wakefield, the highest visible rock or stratum of all the great coal-field of Yorkshire, Derbyshire, and Nottinghamshire, might be found, and ought to be carefully sought for and ascertained; but which interesting service to science has not yet been performed I believe.

The late Mr. Edward Martin, whose excellent brief account of the South Wales coal-field is printed in the Philosophical Transactions for 1806, has described its highest valuable seam of coal to be found, only in a local patch or hummock, between Neath and Llanelly, but has not mentioned the place; nor has he traced the bottom line of the trough, which he merely says, "may be drawn in an east and west direction through the middle of the basin." In May, 1806, Mr. Martin favoured me, by tracing the trough-line on my large map of England and Wales, by Cary, from which I beg here to record its range. Commencing westward, it enters the southern part of Kidwelly Marsh, passes Penbre, Llanelly, Courty Carney, north of Pentalassa, by Cadoxton, Glyn-Carwg, Llandevodwy, Tonna-yodwr, Eglwysilan, Energh, Bedwas, Mynyddyslwyn, and thence curves up the Ebwith Valley to near Lanhiddel, and there ends, according to Mr. M. the dips of the measures from the north-west, north, north-east, and east, centering there, as the end of the deep line of Trough.

On comparing Mr. Smith's planning of the Pontefract rock with the interrupted and detached observations which I have had opportunities of making in Yorkshire, I beg to point out (truth being my object on all occasions) the following errors, which have been committed in the Yorkshire map, beginning south. The north part of the village of Todwick, which probably stands on the Pontefract rock, has been represented as standing on a hummock of the limestone, but whose edge does not proceed so far westward by near a mile, I believe; and the limestone is here mistakenly represented as detached by the Pontefract rock appearing round it on the east; but the large quarry of limestone (for export by the Chesterfield Canal, see Derb. Rep. i. 411 and 434, and iii. 318), called Pecks Mill, or Dog-kennel; and another quarry in South Anston town, east of the church (i. 411), clearly prove this to be an error.

My unfortunate ignorance of *the unconformable character* of the Pontefract rock, when surveying this border of Derbyshire in 1809, prevented my considering, as now I think probably may be the fact, that from near South Anston town to the town of Rotherham (see Derb. Rep. i. 169), this same rock unconformably stretches out upon the coal-measures, having its western edge in Todwick, Conduit Hill, Aston, Aughton, Treton, Catline, Brinkworth, and Eccleshall, and extends near a mile north-west from Rotherham, along the Doncaster road; and I consider my friend Smith as wrong, in representing the Rother-

ham "red rock" (*g*), and the "Ackworth rock" (*c*) as entering Derbyshire, west of Pebley Lane; believing that these rocks in proceeding southward pass under the edge of the Pontefract rock and disappear before they quit Yorkshire.

The thirteenth grit rock of the Derbyshire series, on which Killamarsh church stands, seemed proved, as well by its basset edge as by the ironstone rakes worked on both sides of it, to range northward by Belk Lane, east of Wales Wood, west of Swallownest colliery, by Park Hill and Folken (and having crossed the Rother), by Orgrave, east of Highhazles colliery, through the western part of Tinsley village (and having crossed the Don), east of Massborough, &c.

On the west and south-west of the village of Kippax, Mr. Smith has omitted to notice a point of the Pontefract rock, which spreads out beyond the village of Great Preston, and has upon it two detached hummocks of yellow limestone, which last he has placed too far north. From Berwick in-elmet, the Pontefract rock has been coloured 1¾ mile too far down the Aberford Vale. At the same time that this remarkable unconformable projection, wants extending 1½ mile further west, so as to surround and underlie four detached hummocks of the yellow limestone, which, most unfortunately, my friend has wholly omitted to notice; because, I think, the sandy rock supporting these four hummocks, and resting upon the edges of five of the gritstone rocks, and six of the coal shales of my Derbyshire series, presents, when taken in connection with the facts of the Garforth colliery, and the "shell ironstone" rake (in my ninth coal shale, Derb. Rep. i. 217 and 414), near at hand, the completest case of *the unconformableness* of the Pontefract rock, and those above it in the new series, which can any where be found in the same space.

The largest and most western of these limestone hummocks lies on the north of Seacroft village, and east of *Roundsay* Farm, which last gives name to the large old shallow quarries worked in this hummock, which is a very flat one, containing apparently only the lower yellow beds (below the "blue beds" mentioned in Derb. Rep. i. 157 and 408, and ii. 409), covered in great part by an alluvial clay patch, which stretches thence north-east for 1½ mile.

The second of these hummocks is around Barnbow houses; Berwick town stands on the next, which hummock is about a mile long north-east and south-west, and half as wide; and the last and smallest of these hummocks lies north of the last, and north and west of the Brooks, meeting on the north of Berwick: it is in part covered by alluvial clay.

The next projection of the Pontefract rock which has been omitted, extends west-south-west from the continuous edge of the limestone, and incloses the conspicuous limestone hummock of Elstoft, where there are quarries; and which limestone is

surrounded by dots for colouring on the map of my friend. In the next place, a hummock of the Pontefract rock has been omitted on the north-west side of Bardsea village (Derb. Rep. ii. 410, note). Another is omitted under East Keswick village; and a point of the same rock, north of the Wharfe River, extending from near Wood Hall, under Carlston Hill House, where there are gritstone quarries in it.

In addition to which, my friend has omitted to show a remarkable *denudation*, through which the Wharfe River passes in Collingham parish; wherein for 1½ mile in a north-west and south-east direction, and a mile in some places, transversely measured, the second coal shale is laid bare of its unconformable coverings. Also the southernmost of two singular hummocks of the limestone on the neck of the Pontefract rock separating this denudated tract from the coal-field, is omitted.

I must now return to the border of Derbyshire, and speak of the rock which Mr. Smith marks (*n*), and denominates "flagstone:"* it is my fourth grit rock (Derb. Rep. i. 164, 423, and 427, &c.), and my third coal shale lies under and west of it, producing, as Mr. S. truly states, "ganister stone," to which I will add, excellent fire clay, which are its chief characteristics. From near Sheffield, past Penistone, Huddersfield, and Halifax, and so on north-westward to near Swill Hill, the range of this fourth rock is shown with sufficient accuracy, except as to the double commencement and western of the two courses coloured for this rock, from Whirlow to Stock Bridge; but the remainder of its course on the map I consider to be completely erroneous.

Near to Swill Hill, this fourth rock has arrived at its most western extension in the bottom of *the general trough in the Yorkshire coal-field*, which *trough-line* ranges from somewhere near South-Elmsal, already hinted at in p. 273, as a place south-east of Wakefield, at the edge of the Pontefract rock, and probably passes Wakefield, Woodchurch, Birstal, and High Farnley, on the north-east in each instance, and thence near Swill Hill, and so on, passing south of Pendle Hill, into the Burnley and Blackburn coal-field, in Lancashire.

From the bottom line of this important trough, near to Swill Hill, the basset edge of this celebrated fourth rock, has a general course of about east-north-east, passing, I believe, along the northern verge of Bradford Dale to the town of Bradford; from whence I have ascertained its course to be along, or not far from, the Toll Road towards Leeds, until within half a mile of Kirkstal Bridge, when this rock descends obliquely under Armley Hall, and crosses the Air River about a mile below the Bridge; from whence its course is for the next mile about north-north-west, between Kirkstal and Burley. From hence an east-north-

* Which is an ill-chosen name; because half a dozen of the lower coal-measure rocks, produce, in particular quarries, excellent flagstones, difficultly distinguishable from those of the fourth rock.

east course is resumed by its basset, passing south of Hedingly village, and north of Woodhouse village, where there are large flagstone quarries in it; and about half a mile north-west from these, on Hedingly Common, fire-clay and ganister are dug in the third coal shale, and coarse third grit, north of this, near Mean Wood (see Phil. Mag. vol. xxxix. p. 102).

From the Woodhouse quarries, this fourth rock passes on the south of Potter Newton and Chapel Allerton, north of Allerton Gledhow, past Rounday flagstone quarries, north of Redhall Houses, by Berkby Farm, past Thorner flagstone quarries; and soon after, this rock, with an easy dip about south-east, disappears* under the edge of the unconformable Pontefract rock, on the south of Thorner village.

The northern edge of the third grit rock, from the excellent and well-known quarries at Bramley Fall, by the Leeds and Liverpool Canal, declines obliquely, and crosses the Air River, about a mile above Kirkstal Bridge: thence its course is up Hascar Wood, and proceeds thence mostly with a very bold and decided northern edge, until, on the south side of Bardsey village, this rock also disappears under the Pontefract rock, in the same place and manner, as Mr. Smith has mistakenly shown, with regard to the lower or northern edge of the rock (i), which he calls the "Bradgate rock;" but why it is so named I do not know.

The existence of ganister (galliard, or crowstone), and the prevalence of clays adapted to the uses of the potter (like those of Newton, anciently), and the makers of furnace bricks, lying as floors to their coal seams, has been ascertained at short distances, throughout the course between the third and fourth grit rocks, indicated above, as regularly here as in Derbyshire (almost to the neighbourhood of its county town), wherein, these important features of the coal series were first ascertained, and such details published in its county report, as can leave no kind of doubt on the subject.

In the manner above described, the strata northward, continue to have a south-eastern dip (which would have been a south-south-west dip, but for the deepening of the trough line in each stratum, to the east-south-east, or nearly) into the great trough of coal-measures herein described; in consequence of which, my second grit rock approaches and passes under the Pontefract

* There can be little reason for doubt, that after the basset edge of this fourth rock has passed some distance under the yellow limestone, it turns northward, and has an uninterrupted course under its unconformable cover, into Durham, and that there, somewhere near to Morton, Bolam, or Brusselton, this important rock emerges again from under the Pontefract rock, and has doubtless a long course across that county and Northumberland, which course I could ascertain and depict as certainly, I think, as several years ago I did, as to 94 miles of its course across Derbyshire and Yorkshire (see Phil. Mag. vol. lxxxix. p. 102), and as to a great many miles of its course in Flintshire (see Phil. Mag. vol. xlv. p. 166). Why has this matter slept, and no one attempted to map the gritstone rocks of the Wear and the Tyne coal-field?

unconformable rock, somewhere about the junction of the sheets of Mr. Smith's map, perhaps, leaving then my first coal shale on the surface, in contact with and passing under the Pontefract rock; and it is this coal shale which, in such case, produces the Harrowgate medicinal spaws: unless indeed both the second and the first grit rocks have passed under the Pontefract unconformable rock, before we arrive so far north as these spaws?; under which last circumstances, these celebrated springs will be referable to my "limestone *shale*."

But whichever of these may, on a rigid investigation, prove to be the fact, it will, I think, certainly result, that a *strata ridge* (which may not be easily definable by a line on the map, or without careful levellings, owing to this ridge in the upper measures, having an irregular rounding summit), will be found emerging from under the edge of the Pontefract rock, somewhere not far from Thornton Chapel; and, proceeding westward by Pateley Bridge, there, either my shale *limestone* or the first limestone rock emerges on the surface of this ridge in a local denudation, extending to near Raven's Cross: thence this strata ridge probably declines southward, and ranges through the smaller denudated tract of limestone, north-east of Barden; then bending again northward, it probably, near Burnsal, enters a more extensive denudated tract, proceeds, perhaps, by Kirkby-mallam Dale, and then bends so much northward as to pass Settle, and proceeds on the north of Clapham and Ingleton; passing thus north-east of, and occasioning the dip south-westward into the Black Burton coal-field.

Generally speaking, the strata ridge last described should be considered as the boundary northward, of the great Yorkshire coal-field; and that to the northward of this strata ridge, a district of undulating strata commences, and the same are disposed in several strata troughs, ranging eastward and westward, and are separated by corresponding strata ridges, through the remainder of the county; and, perhaps, it is the same in the south-western parts of Durham. On this principle I should, if entering on a survey of the local coal-fields of this northern part of Yorkshire, search northward of Thornton Chapel, before conjectured to stand on the great strata ridge, for the emerging of the first grit rock * (dipping north-eastward, and covered more northerly by the first coal shale†) from under the unconformable

* My first grit rock may probably be comprised in Nos. 104 to 95 in Mr. W. Forster's "Section."

† Part of my first coal shale probably appears in his Nos. 94 to 91, and the remainder of this shale is omitted, I think; especially as Mr. F. himself, in p. 93, suspects some strata to be here omitted; but the number and thickness of these (including, probably, I think, my second and third grit rocks, and the intervening second coal shale) are, perhaps, much more considerable than he is aware of. Where is the *gannister* found? or its peculiar species of leafy *reeds*?, or the two species of *marine shells*? enumerated in p. 243, vol. i. of Mr. Sowerby's "Mineral Conchology," in the counties of Durham or Northumberland?; and is this stone there any where applied to the making of roads?

Pontefract rock; and this first grit rock, I doubt not it would appear to be which my friend has represented as surrounding westwardly the trough of lower coal measures on the west of Masham; but which rock mistakenly has been coloured as a continuation from Swill Hill, mentioned p. 275, of his "flagstone rock," answering to my fourth grit.

Similar remarks apply to the smaller coal trough on the west of Patrick Brompton, although its strata are in part covered and superficially bounded on the east, by unconformable upper red marl, overlapping previously the yellow limestones and their intervening gypseous marl, and then the edge of the Pontefract rock, in these parts.

I will now only further remark, that the cause of the disappointments seems now apparent, from the boreings made some years ago in search of coals on the west of East Rigton village, south of the Wharfe River, and westward of Sicklin Hall and Spofforth, on the north of the river, as well as those older trials doubtless made, but, perhaps, not recorded, in the Collingham denudation, mentioned p. 275, viz. that *no thick or valuable seams* of coal occur, *in so low a part of the carboniferous series*; but which spots, even yet, it would seem, my friend considers to have strata higher in the series than the fourth grit rock, the usual limit downwards, in these parts, of marketable seams.

I am, Sir, yours, &c.

John Farey.

Article VIII.

Memoir illustrative of a general Geological Map of the principal Mountain Chains of Europe. By the Rev. W. D. Conybeare, FRS. &c.

(*Continued from* p. 218.)

*** In citing the authority of Boué as confirming the opinions of Prof. Buckland and myself, with regard to the distinction between the todteliegende and old red sandstone of England, I was not aware that he had formerly entertained different views; this I have since learned from his memoir on Germany, inserted in the volume of the Wernerian Transactions recently published. That memoir, however, was read in the beginning of 1822, before the appearance of the arguments on this subject brought forward in the "Outlines." Since that period, M. Boué has enjoyed opportunities of studying many other localities of this formation, and has, with a candour that does him honour, made the concession which I have quoted; the letter I have cited bears date Vienna, Jan. 14, 1823. It may be considered, there-

fore, as conveying his matured opinion, and as I have, through his correspondent, his sanction in extracting any observations that appeared to me important, my citation may be regarded as an authentic declaration of his present views. I have thought this explanation necessary to remove any apparent contradiction between it and the memoir alluded to. I need not add that his testimony on my side derives additional weight from the circumstance, that his judgment was not hastily formed, but the result of a slow conviction.

The Series of Lias and Oolites, Muschelkalk, and Jura Kalkstein.

This system viewed generally consists of a series of alternating deposits of clay, and of limestones of a texture considerably more earthy and less compact than those of the preceding epochs, and often oolitic. These are strongly contrasted also with the earlier formations in the very important circumstance of their zoological character, I mean the nature of the organic remains which they contain, as they appear to preserve the traces of a very different and more advanced state of animal population in the waters beneath which they were accumulated. In speaking, however, of the earlier formations, I would be understood to mean those earlier than the alpine limestone; for the alpine limestone is clearly in this respect connected more nearly with the subsequent than antecedent order of things; and these observations should, therefore, in strict propriety, have stood at the head of that formation; but since the organic remains in that series are rather of local than common occurrence; whereas in the present they form a striking and general character, this deviation from the rigour of method may be excused. The vertebral class, of which rare and faint traces alone occur in the older rocks, presents in these a rich and most interesting addition to the lists of animals now existing; these principally belong to the order of oviparous and amphibious animals; but exhibit in some instances an organisation which would fit them rather for a life entirely aquatic than one divided between both elements (e. g. the ichthyosaurus), and appear to bear the same relation to the actual genera that the cetacea do to other mammalia: others, however, are like their recent antitypes fitted for moving both in the land and water. In this zoology of a former world, we count several species of the crocodile (England and France afford four at least which may be distinguished): these do not agree specifically with any of the varieties now known to exist; but the differences are very slight, often indeed less marked than between the recent species; there is no room, therefore, to doubt that their general habits were similar. Were these species capable of enduring the cold of high latitudes, and there hatching their eggs? or did they migrate? or was the temperature of our planet then higher than at present? Some varieties

of recent crocodiles have been found out at sea a considerable distance from the land. It becomes the inquisitive spirit of science to propose these problems;—it becomes the modesty of that spirit to hesitate in attempting (without more ample data than we at present possess) their solution. Many other genera referable to the great order of the lizard family, but evidently partially or entirely aquatic, which have either entirely vanished from, or (and this is from their bulk and striking appearance very improbable) remain undetected in the actual state of animated nature, are preserved in these beds to exercise the researches of the comparative anatomist. We already reckon, and the subject is yet far from exhausted, four distinct genera of this kind (1. The fossil saurian, of Maestricht; 2. That of Stonesfield, megalo saurus; 3. The plesio saurus; 4. The ichthyosaurus); many of these, the latter especially (which unites to the head of a lizard the vertebral column of a fish, and combines the modes of progression peculiar to each), present links as important as striking in the great chain of animal being: the lines of Lucretius are, therefore, in one sense* philosophically true:

> Multaque tum tellus etiam portenta creare
> Conata 'st mirâ facie membrisque coorta,
> Multaque tum interiisse animantum sæcla necesse est.

Turtles more or less approaching to the recent are likewise found. Here again we have some presumption, though certainly no proof, of a warmer climate.

Mingled with these remains (though in such small quantity as to show that they have been casually brought from a distance, while the former are found under circumstances which indicate their having lived and died in their present sites), are the disjecta membra of land animals (the didelphys of Stonesfield), of birds (also Stonesfield), and of coleopterous insects (also Stonesfield), sufficiently proving that the earth and air were peopled with life as well as the waters.

The vegetables of this series are dicotyledonous as well as monocotyledonous. The shells are characterized by the disappearance of many of the genera, and most of the species, belonging to the transition and carboniferous series, and the introduction of many new genera, almost all the species being also new; scarcely indeed a single species can be identified. The same remark applies equally to the zoophytes.

In one instance, that of the encrinites, Mr. Miller has made an observation as important and beautiful as it is original. This very interesting order of animals considered merely in the relations of

* Not certainly in that which bears an aspect favourable to materialism, for it is impossible to point out instances of design more striking or beautiful than are often exhibited in the structure of these fossil animals. Thus much even in the present obscurity of the subject we can perceive; and did we fully know the various revolutions of our planet, we should doubtless find fresh reason to admire the adaptation of its living occupants to its existing state at every successive period.

this structure, divide themselves into two well marked and distinct series. Now of these one only is found in the older rocks; the other is confined to those more recent than the coal formation. It is very probable that ulterior researches may extend similar conclusions to many other classes; it is impossible that the subject should be in better hands than those of the author just alluded to, whose unwearied patience in the investigation of those minute details which afford the only sure grounds for such an induction, is joined to that philosophical spirit of generalisation which can alone combine them into a luminous system.

The series of this system in England where it has been most fully studied, consists of three great deposits of a calcareo-argillaceous character, alternating with three others of calcareo-siliceous matter and of oolitic limestones.

1. Upper Oolitic system.	*a.* Argillo-calcareous Purbeck strata, separating the iron sand and oolitic series. *b.* Oolitic strata of Portland, Tisbury, and Aylesbury. *c.* Calcareous sand and concretions (Shotover hill and Thame.) *d.* Argillo-calcareous formation of Kimmeridge and the vale of Berks, separating the oolites of this and the next sytem—Oaktree clay of Smith (generally).
2. Middle Oolitic system.	*a.* Oolitic strata associated with the Coral rag (Pisolite of Smith). *b.* Calcareous sand and grit. *c.* Great Oxford clay (Clunch clay of Smith) separating the oolites of this and the next system.
3. Lower Oolitic system.	*a.* Numerous oolitic strata, occasionally subdivided by thin argillaceous beds; including the Cornbrash, Forest marble, schistose oolite and sand of Stonesfield and Hinton, great oolite, and inferior oolite. *b.* Calcareo-siliceous sand, supporting and passing into the inferior oolite. *c.* Great argillo-calcareous formation of lias and lias marle, constituting the base of the whole series.

N. B. This list is in a descending order.

The most probable analogies of these with the continental formations appear to be the following, in which I have inverted the preceding order, and followed the ascending series.

1. *Lias* (3. *c*), *Muschelkalk, and inferior Beds of the Jura Limestone.*—There is still some doubt whether the term muschel-

kalk may not be applied to more than one formation;* first, it is sometimes applied to the Wurtzbourg limestone, which Keferstein classes with the alpine, and which has, therefore, been so coloured in the accompanying map on his authority, though I have already expressed my own inclination to consider it as representing our lias. Secondly, there is less doubt that the rocks to which the name muschelkalkstein have been applied in the north of Germany (where, I believe, it was originally adopted) are equivalent to our lias. Thirdly, it is certain that most of the beds commonly included under this designation on the north-west and north of the Jura chain and the Rauhe Alp, extending into Wurtembourg, &c. are identical with our lias, as also the beds underlying the oolites of the cotè d'or in the north-east of France, extending towards Metz, &c. &c.

2. *Sandstone of the inferior Oolite* (3 *b*).—Arenaceous and iron shot beds are interposed between the Jura lias and oolites near Lons le Saulnier, and through the whole northern escarpment of that chain, and its prolongation the Rauhe Alp (*Eisen sandstein of Keferstein*). According to Haussman and Keferstein, the quadersandstein in the north of Germany is similarly placed; but I suspect that more than one formation may be confounded under this denomination, and the local circumstances under which it occurs are such as to render the determination of the question difficult.

3. The other divisions of the series, including all the beds which, properly speaking, can be termed oolites, resemble one another so much that their individual identification with those of the Continent can hardly be expected in the present state of science; if indeed, which seems very questionable, a close agreement in these minor features of arrangement really exists, through very extensive tracts, and in very distant sites. Such a

* M. Boué appears to be of opinion that the muschelkalkstein of Central Germany is not our lias, but a formation wanting in England, and intermediate between the new red sandstone and lias being separated from the latter by the quadersandstein; so that the ascending series is: 1. New red sandstone; [2. Muschelkalkstein; 3. Quadersandstein] 4. Lias and oolites, the formations between brackets being absent in England. He cites a section near Amberg in confirmation of this position. This debateable ground refers principally to the Wurtzbourg district, and the country extending thence towards the frontiers of Bohemia. I feel that it is more important at present to state difficulties of this kind than attempt an hasty solution. I shall return to this subject in tracing the course of these formations; on the whole I certainly incline to the view which I have indicated in the text. Those who distinguish the muschelkalk as a peculiar formation refer to two principal localities; first, the platform of Wurtzbourg (which has been just mentioned); and, secondly, in the North of Germany, at Goettingen, &c. they consider it as characterized from the lias by the absence of the alternating argillaceous strata so common in that formation. It is an earthy limestone, generally of pale colours (greyish or yellowish), has some subordinate marly, arenaceous, and oolitic beds, with occasional layers and nodules of chest; its peculiar petrifactions are: Chamites striatus, Belemnites paxillosus, Ammonites amalteus, A. nodosus, A. angulatus, A. papyraceus, Nautilites binodatus, Buccinites gregarius, Trochilites lævis, Turbinites cerithius, Myacites ventricosus, Pectinites reticulatus, Ostracites spondyloides, Terebratulites fragilis, T. vulgaris, Gryphites cymbium, G. suillus, Mytulites socialis, Pentacrinites vulgaris, Encrinites liliiformis. See also the note of M. Boué on the north of Germany.

correspondence, however, may certainly be traced on the opposite shores of the British channel, and there seem to be strong indications of the same kind in the Jura chain.

Distribution of this Series.

(A.) *England.*

A line drawn from the north-east of Yorkshire to the south-west of Dorsetshire will nearly indicate the western and inferior limit of this series. The lias, however, extends westwards from this boundary on both sides the British Channel in Somersetshire and Glamorganshire. The eastern and superior limit follows a line nearly parallel to the former, and between 20 and 41 miles to the south-east of it. The three systems of oolites form as many parallel ridges of hills separated by intermediate valleys, following the course of the intermediate clays. The great or third oolitic system forms the most extensive and continuous of these ranges. The chains presented by the other two are more partial, and interrupted through considerable intervals.

(B.) *Other British Islands.*

The British Islands present no traces of these formations beyond the limits above assigned, with the exception of the lias, which occurs in Ireland in the county of Antrim, near the south-east border of the basaltic district; in the Isle of Sky, and some other of the Hebrides.

(C.) *France.*

1. *In the Denudation of Boulogne.*—The escarpment of the chalk sweeps round a semicircular tract, in the centre of which this town is placed, with a radius of about 12 miles distance. The green sand follows the fort of this escarpment, and may also be traced on the north-east of Uissant, and the hills close to Boulogne, on which Buonaparte's tower is built, are capped with strata of ferruginous sand, possibly our own iron sand. But instead of these formations occupying, as in the corresponding tract in Kent and Sussex on the English side, the whole of the denuded area, we find the coast, through the greater part of its breadth, lined with a calcareo-argillaceous formation which underlies the sand last mentioned; this may be studied in the cliffs on either side of Boulogne, which, however, are, from the nature of the material, in a very crumbling state.

One of the upper beds of this formation consists of a remarkable calcareo-siliceous grit. Boulogne is principally built of this rock. It often forms the upper stratum of the cliffs on the north-east of that town, and is particularly abundant at a place called le Creche, between it and Uissant. This rests on some beds of argillaceous limestone, separated by clay; and along the

bottom of this cliff is found a coarse limestone of a brown colour, full of cornua ammonis, turbinated univalves, &c.

These alternations of argillaceous and calcareous beds continue to extend into the interior towards the east of Boulogne. In a deep pit sunk at Souverain Moulin, about five miles from the town in that direction, in a fruitless attempt to procure coal, the workmen passed through 12 such alternations, and then pierced a solid calcareous rock 100 feet in thickness, containing ammonites. Below this, occurred a thin seam of wood coal, and then 20 feet of a shelly limestone full of turbinated univalves, small oysters, serpulæ, &c. together with impressions of ferns and other vegetables; and, lastly, another thin seam of carbonized wood, resting on coarse limestone.

The coral rag is exhibited with well-marked characters about nine miles south-east of Boulogne, near Samers, and the great oolite may be seen in the country round Marquise at the same distance on the north-east. Both these points approach very closely to the chalk escarpment; so that if the green sand, iron sand, &c. exist at all in these directions, they must be greatly reduced in extent.

Near Marquise, the oolite comes in contact even with the older rocks of the coal formation, which show themselves in this corner of the denudation almost immediately beneath the chalk. This coal district presents a band of mountain limestone accompanied by another of regular coal-measures. The principal marble quarries are at Ferques, and the principal coal mines at Hardingen. The stratification is extremely confused and contorted.

2. Within the interior area of the basin of Paris, there is also a small denudation exposing the oolites, in a district called the Pays de Bray, a little north-west of Beauvais.

3. *Surrounding the Chalk and Green Sand of the Paris Basin.*—This series also may be seen emerging from beneath the chalk in the coast westwards from the mouth of the Seine, where they have been traced by M. de la Beche.

Along the mouth of the Seine, on both sides, the chalk and green sand repose on a blue marl and marl-stone. At Trouville sur Mer, the oolites of the upper and middle formation, i. e. the Portland stone and coral rag, emerge from beneath this marl. Between Villers sur Mer and Dives, the clay separating the second and third system (the Oxford clay) forms the base of the cliffs, which are capped by the lower beds of the coral rag, and an overlying mass of green sand. Still further west by St. Comme, Arromarche, St. Honorine, Virreville, and Grandcamp, the cliffs present the inferior oolite resting on lias.

Hence, a zone of these formations extends circling round the chalky and arenaceous border of the basin of Paris, by Caen, Alençon, Poitiers, Bourges, Auxerre, Bar le Duc, and Mezieres, the oolites stretching beyond all these places, succeeded at a

wider distance by the subjacent lias; and still further by the red marl, which, with a few occasional interventions of coal-measures, reposes on the transition and primitive chains of Bretagne and la Vendée on the west; of Limousin, Auvergne, Forez, Beaujolais, and Morvan on the south, and of the Vosges on the east.

The oolites of this range form the lofty hills known by the name of cote d'or. Here the oolites approach closely to the primitive chain of Morvan. M. Boué says, that the muschelkalkstein may be traced completely round the Vosges.

4. *South of France surrounding the Basin of the Garonne.*—The tertiary basin of this district is described by M. Boué as limited by Bayonne, Carcassouc, Montaubon, and Talmont. This is succeeded on the north by Jura limestone, covered by iron sand, &c.

In approaching the Pyrenees, he has observed a band of Jura limestone succeeded by quadersandstein with lignite, reposing in some places (as near Dax) on muschelkalkstein.

(D.) *Northern Germany.*

The muschelkalkstein is here found among the formations skirting the Hartz, both on the north and on the south, ranging in the former direction on the south of Hanover and Brunswick,* and on the latter forming a platform in the country between the Hartz and the Thuringerwald, on the escarpment of which it is

* M. Boué in one of the letters to which I have so often referred gives the following description of the muschelkalkstein of Brunswick, which is the best I have yet seen.

"This formation lies above the variegated sandstone. Its organic remains are encrinites and pentacrinites, some species of terebratula, especially the subrotunda and carnea, pectines, venericardiæ? a bivalve badly preserved and unascertained, but generally and loosely classed as musculites, an univalve approximating to turbo, an ammonite not carinated, a small indistinct univalve, uncertain whether nautilus or serpula, and many singular markings in the form of elongated and serpentine cylinders which might be, perhaps, considered as merely accidental configurations of the calcareous paste, but yet from their ramification, &c. assume an appearance resembling that of the Isis tribe. The masses of lead glance, occasionally found in this formation, at once distinguish it from the Jura limestone, yet in the lowest members of this muschelkalk are portions of an oolitic texture closely associated with the subjacent variegated sandstone.

"Above it lies an argillaceous, calcareous, and arenaceous formation, in which slate clay, more or less bituminous, alternates. In the under part, it alternates with a few beds of a limestone like the muschelkalk, but without shells; in other parts, and especially in the upper, with a compact sandstone, with a calcareous or argillaceous cement.

"The whole is covered with the quadersandstein, a formation often with a siliceous cement, and very compact, but at other times of very slight coherence. Associated with and beneath this formation, I observed two beds of a compact calcareous marl, with fragments of pinna, retaining their shelly texture, and not petrified.

"The argillaceous formation contains in the bituminous portions mineral charcoal, fragments of bituminous wood, and a kind of pitch coal used in some places as fuel, and impressions of monocotyledenous vegetables.

"Ammonites (of the subdivision planulites), of small size, occur abundantly; but are confined to particular beds; in others a large common ammonite with sound back and not carinated is found in ironstone nodules. I observed also a species of terebratula? or, perhaps, gryphites; one or two species of donax; three or four unascertained bivalves; an univalve somewhat resembling clasilia; and more rarely remains of very fine pentacrinites."

well exposed in the descent from the memorable planes of Jena. It is covered by quadersandstein, on which, according to Haussman, Keferstein, Boué, &c. repose in the north of Germany marls, oolites, ferruginous oolites, and chalk.

Some observations of Prof. Buckland indicate considerable derangement in the Brunswick district; a ridge of chalk extends on the north of the Hartz towards Goslar, often in highly inclined beds, and forming a hog's back; yet on the north of this, where the more recent deposits might be expected, the variegated sandstone again protrudes.

South of the Thuringerwald, the same muschelkalkstein extends by Heldburghausen and Cobourg.

(E.) *Central Germany.*

According to Boué and Humboldt, the platform of Wurtzbourg considered by Keferstein as zechstein, or alpine limestone, is muschelkalkstein. I have already alluded to its position in describing the alpine limestone. If this view be correct, the sandstone between Wurtzbourg and Bamberg is not, as represented by Keferstein, buntersandstein, but quadersandstein.

(F.) *Great Range of Franconia, the Swabian and Rauhe Alp, and the Jura Chain.*

This is an immense and continuous band principally occupied by the oolitic series, crowned in some places by still more recent deposits of the same age with the chalk marl, &c. of England.

In the most northerly part of its course through Franconia, it forms the platform between Bamberg and Bayreuth. We have here a compact limestone (celebrated for its caverns containing the remains of fossil bears), &c. a sandstone, and some marly beds much resembling in fossils and character our chalk marl: this system rests on the sandstone extending between Bamberg and Wurtzbourg. It is to be regretted that the obscurity which still hangs over the relations of this tract affects equally the superincumbent limestone, &c. Boué considers this sandstone as quadersandstone and the limestone as representing the whole oolitic series.

Further south, he gives the following as the section presented near Amberg: 1. Quadersandstein. 2. Ditto with hydrate of iron. 3. Lias, with gryphœa arcuata, gryphœa gigas, belemnites, &c. 4. Argillaceous rocks with hydrate of iron, ammonites, mya, cerithia, &c. 5. Several varieties of Jura limestone, magnesian compact, and oolitic. 6. Marl, with hydrate of iron. If the gryphœa gigas be the same with the gryphœa dilatata. This series is in the ascending order.

I should prefer considering the deposit No. 2 as our Oxford clay. I should then identify the deposit here called quadersandstein

with the sand of the inferior oolite, and reckon the subjacent Wurtzbourg muschelkalk as the equivalent of our lias. Nos. 3, 4, 5, would then represent the oolites of our middle or upper system; but these are points which cannot be fully settled until resident geologists shall arise on the spot, and publish detailed accounts of its structure and fossils.

Near Ratisbon the Jura limestone is covered, according to Buckland and Boué, by deposits of green sand and chloritose chalk; the solenhofen lithographic strata belong, I believe, to one of the beds in the upper part of the series of Jura limestones, perhaps corresponding to our chalk marl.

Here the beds decline to the south, plunging beneath the trough of tertiary formations which intervenes between this chain and the Alps, and rising north, present their outcrop in the escarpment on that side.

In its passage through Wirtemberg, the chain presents, along the base of its northern escarpment, decided lias at Boll, &c. south of Esslingen; a ferruginous sand (that of our inferior oolite) succeeds; and then the oolitic series forming the great mass of the hills.

By tracing this escarpment from this point to Bamberg, and examining the relations of the Wurtzbourg platform with reference to this chain in the vicinity of Stutgard, much of the obscurity I have alluded to would probably be removed; because we here stand on certain ground as to the identity of the Boll rocks and the English lias, which would afford a secure basis to the other terms of the comparison.

Merian is said to have published a good account of this chain in the vicinity of Basle,* but I regret not having been able to consult it.

There is a very interesting description of the part of this chain near Lons de Saulnier by Mr. Charbant, in which it appears that its base is composed of red and variegated marl containing gypsum; that on this reposes an extensive formation of beds of gryphite limestone (lias), alternating with marls containing fossils exactly similar to those which characterise this formation in England; that these are covered by a series of oolitic beds, the lowest of which (like our inferior oolite) abounds in ferruginous particles, and is surmounted by a fine granular oolite and freestone, forming the escarpment of the first terrace of these hills; and lastly that, above this first terrace, are others each presenting an oolitic series based on argillaceous beds which separate it from that beneath.

We have here, therefore, the enumeration of the lower forma-

* The denudation of the Rhein, that near Basle, exhibits a patch of primitive and transition rocks, over which the calcareous beds of the Jura extend. This patch is probably connected with the primitive rocks which further north emerge in the chain of the Black Forest.

tions of the Jura chain, where they crop out along the base of its escarpment on the north-west; and an account by Von Buch of the environs of Neufchatel completes the account by adding the beds in the central and south-eastern regions, where they finally dip beneath the tertiary formations. He divides these formations into four series which he enumerates in a descending order. I have ventured to assign their probable English equivalent, but these can only be considered as mere conjectures at present.

First Series.

29 beds of oolites contain madrepores, &c.	Coral rag.
Upper marl	Oxford clay.
32 oolitic beds.	Cornbrash.
Second marl.	Clay beneath the cornbrash.

Second Series.

486 more compact beds, some of which contain strombites	Forest marble.

Third Series.

350 oolitic beds	Great oolite.
60 beds hard black marl	Clay of the fuller's earth.

Fourth Series.

100 beds not described, probably the same with those above Lons le saulnier	Inferior oolite and lias.

The Jura chain exhibits arched and contorted stratification through its central ridges; but on the north-west all the beds crop out, and on the south-east dip rapidly beneath the tertiary formations which occupy the great valley of Swisserland separating these ridges from the Alps. The exterior chains of the Alps again exhibit in what have been called the younger varieties of alpine limestone, beds of the same age with the above.

On the south of Geneva, the continuation of the Jura chain unites with these external calcareous chains of the Alps; and in this vicinity, therefore, the true relations of the several formations ought to be particularly examined. Hence they are continued south through Dauphiny and Provence, but I am not acquainted with any good account of their structure in this quarter.

(G.) *The Alps.*

For an account of these formations in the external chains of the Alps, I refer entirely to the excellent paper of Prof. Buckland, which has already appeared in the *Annals*.

(H.) *Hungary.*

According to Beudant, rocks referable to the Jurassic series occur principally in two localities; first, on the south-west, extending northwards from Lake Balaton or Platten; and secondly, on the south-east towards the borders of Transylvania above the sources of the river Korosh.

He gives the following list of these formations:

1. An encrinal limestone (most probably the muschelkalk): this is most abundant in the second district, but occurs also in the first; it is covered by

2. A magnesian limestone: not the same with the English magnesian lime or zechstein, but associated with, and constituting a part of the true Jurassic limestone which covers it: it exhibits three varieties: *a.* Saccaroidal; *b.* Compact; *c.* Oolitic. This formation abounds in the first district between Bude and Lake Balaton.

3. Jurassic limestone: *a.* Containing hippurites; *b.* With great oysters; *c.* With nummulites; *d.* Abounding in shells; *e.* Bituminiferous. This exists in many patches throughout the first district between Gran and Lake Balaton.

(I.) *Russia, and other imperfectly ascertained Localities.*

In Russia, the lias certainly occurs near Moscow, but we have no distinct particulars concerning the secondary formations of that vast country.

The tracts of these formations in England, France, Germany, and Russia, may be considered as parts of a continuous series of deposits occupying the great central basin of Europe. That on the Italian side of the Alps, although necessarily mentioned in connexion with that chain, belongs to a distinct and southern basin, of which a great part of Spain also probably forms a portion. Much of the limestone of that country may perhaps prove to be lias, and the oolites are distinctly described by Mr. Townshend as extending round Anchuela del Campo, about half way between Saragossa and Madrid.

(*To be continued.*)

Article IX.

An Account of some Results obtained by the combined Action of Heat and Compression upon certain Fluids, such as Water, Alcohol, Sulphuric Ether, and the rectified Oil of Petroleum. By M. le Baron Cagniard de la Tour.*

It is well known that by means of a Papin's digester, the temperature of fluids may be raised much above their usual boiling point; and we are led to suppose that the internal pressure which increases with the temperature would be an obstacle to the total evaporation of the fluid, especially if the space left above the fluid be not considerable.

In reflecting on this subject, it occured to me that the expansion of a volatile fluid had necessarily some limit, beyond which the liquid, notwithstanding the pressure, must be converted into vapour, little as the capacity of the apparatus allows the fluid to extend beyond its maximum of dilatation.

In order to verify this opinion, I put some alcohol of specific gravity 0·837, and a ball or sphere of quartz, into a small Papin's digester made of the end of a very thick gun barrel; the fluid occupied nearly one of the apparatus. Having noticed the kind of noise which the ball occasioned while rolling in the cold gun barrel, and afterwards when it was slightly heated, I arrived at a point in which the ball seemed to rebound at each percussion, as if it was no longer surrounded by a fluid in the gun barrel. This effect was best observed by applying the ear to the end of the handle, which served to support the machine; it ceased upon cooling, and was reproduced when the necessary degree of heat was again applied.

The same experiment was repeated with water, but with imperfect success; for on account of the high temperature which it was necessary to employ, the apparatus could not be perfectly closed. With sulphuric ether and oil of petroleum, the case was different; they presented the same phenomena as alcohol.

In order to observe these effects of heat and compression with greater facility, I put the same liquids into small glass tubes closed at one end, and afterwards at the other, by means of the blowpipe. A small piece of glass was fastened to each tube to serve as a handle.

One of the tubes into which alcohol was introduced so as to occupy nearly two-fifths of it, was heated with the precautions requisite to prevent its being broken; in proportion as the fluid expanded, its mobility became greater; the fluid after having attained

* From the Annales de Chimie et de Physique, tom. xxi. p. 127.

nearly double its original volume, disappeared completely, and was converted into so transparent a vapour that the tube seemed suddenly empty; but on suffering it to cool for a moment, a very thick cloud was formed, after which the fluid reappeared in its original state. A second tube, nearly half full of the same fluid, gave a similar result; but a third, of which the fluid occupied more than half, was broken.

Similar experiments made with oil of petroleum, of specific gravity about 0·807, and with ether, presented analogous results, excepting that the ether appeared to require less space than the oil of petroleum to be converted into vapour without breaking the tubes, and the latter less than alcohol, which seems to indicate that the more a fluid is naturally dilated, the less volume it takes to attain its maximum of expansion.

All the tubes in these trials were exhausted of air before they were closed; the experiments when repeated with tubes in which the air was left, gave similar results; the progressive expansion of the fluid was even more easily estimated in the latter case, there being no inconvenient ebullition as in the former.

The last experiment was made with a glass tube about one-third full of water; this tube lost its transparency, and broke a few seconds afterwards. It appears that at a high temperature water is capable of decomposing glass by combining with its alkali; this suggests the idea that some other result interesting to chemistry may, perhaps, be obtained by increasing the applications of this process of decomposition.

By carefully observing the experimental tubes in which the air had been left, it was remarked that those in which the fluid matter had not quite space enough to acquire the dilatation preceding its conversion to vapour, did not always break immediately after the fluid appeared to have completely filled this space, and the explosion was slower as the excess of fluid was less apparent.

May it not be concluded that fluids which are usually but slightly compressible at a low temperature, become more so at a higher temperature? and still more strongly in the present case, in which the liquid is ready to become an elastic fluid under a pressure, which, according to theoretical calculations, would appear to be equal to several hundred atmospheres?

With respect to this, there will probably be some difficulty in admitting, that a small glass tube scarcely three millimetres in diameter, and scarcely one millimetre thick, should resist so considerable an expansive force; it will, perhaps, be thought preferable to suppose that the molecules of an elastic fluid, and particularly of a fluid vapour, are susceptible at a certain degree of compression and heat, of assuming a change of state similar to semifusion, and capable of facilitating a greater reduction of volume than that derived from the absolute pressure.

Until these doubts are removed by new experiments, it appears that we may recapitulate what has been stated in the following conclusions:

1. That alcohol of specific gravity 0·817, oil of petroleum of specific gravity 0·807, and sulphuric ether, submitted to the action of heat and compression, are susceptible of being completely reduced to vapour under a volume rather exceeding twice that of each fluid.

2. That an increase of pressure occasioned by the presence of air in several of the experiments which have been described, occasioned no obstacle to the evaporation of the fluid in the same space, that it merely rendered its expansion more quiet and more easy of observation until the moment in which the fluid suddenly disappeared.

3. That water, although undoubtedly susceptible of being reduced to very compressed vapour, could not be subjected to complete experiments for want of sufficient means to close the compressing instrument perfectly, as well as that it alters the transparency of glass tubes by combining with the alkali which enters into their composition.

I have presumed that this notice would particularly interest those who are concerned in the use of steam-engines, and also probably furnish some slight indications for the solution of the question relating to the compressibility of fluids, lately proposed as a prize subject by the Institute; it is this which determined me to present it to the class, my chief ambition being to prove, that I desire to render myself more and more worthy of the favourable reception which it has bestowed upon my former labours.

Supplement to the preceding Memoir.

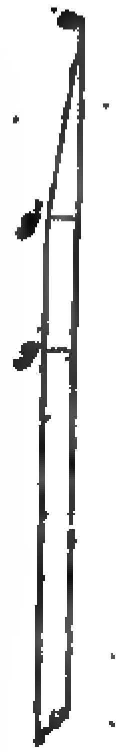
I have attempted to determine the pressure which ether and alcohol exert at the moment in which these fluids are suddenly reduced to vapour. The method I adopted was the following:

Exper. 1.—I took a tube, *a b c* (see fig. next page), of the most even bore I could obtain, the interior diameter of which was one millimetre; I united it to the tube *d e f*; the internal diameter of which was about 4¼ millimetres. The apparatus then resembled a syphon barometer. The two ends, *a* and *f*, remaining open, mercury was first introduced, and afterwards sulphuric ether. The mercury occupied the space *b c d e*, and the ether the space *e f*; by inclining the apparatus, it was easy to alter the level of the mercury so as to fill the space *b a*; by these means it was ascertained that a variation of one millimetre in the large tube, caused a variation of 20 millimetres in the smaller one; a proportion which was judged sufficient for the graduation required. The space *b a* is that which the mercury may occupy, when its level *e* in the large tube is sunk to the point *d*, the length *a b* is

528 millimetres; the space $d\,f$ double $e\,f$, is that supposed to be occupied by the ether when it is entirely reduced to vapour.

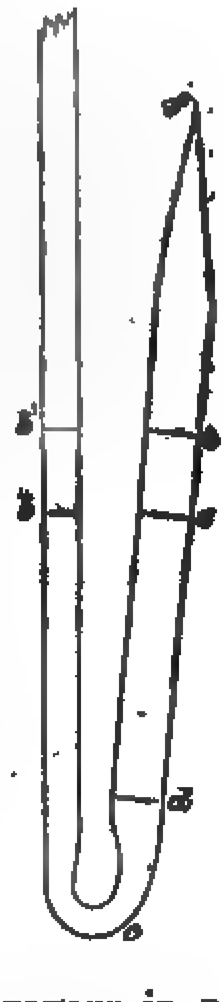
The 528 millimetres were graduated on a separate scale, which was applied when required to the tube, as it was graduated towards the upper part.

The apparatus, prepared as above described, being closed at the extremities a, f, was heated with the requisite precautions. At the moment in which the ether was completely reduced to vapour, the level b of the mercury rose to the point g, the distance of which from the point a is 14 millimetres; *thus the column of air, which was 528 millimetres long, was reduced to 14 millimetres; this indicates a pressure of 37 or 38 atmospheres. This experiment three times repeated gave each time the same result.*



Ether is, therefore, susceptible of being reduced to vapour in a space less than double that of its original volume, and in this state of vapour, it exerts a pressure of 37 or 38 atmospheres in the tube which contains it.

Exper. 2.—Alcohol of specific gravity 0·817 was substituted for ether in the apparatus above described by opening the ends f and a; the alcohol occupied the space $f\,e$, that is to say, one-third of that supposed to be necessary for the total conversion of the alcohol into vapour. The mercury occupied the space $b'\,b\,c\,d\,e'$, and filled the small tube, when, by inclining the apparatus, the level e' was sunk to d. The length of the column of air $a\,b'$ was 476 millimetres. After the extremities a and f were closed by the blowpipe, the apparatus was exposed to heat with the same precautions as observed with respect to the ether. At the moment in which the alcohol was totally reduced to vapour, the level b' of the mercury rose to the point g', that is to say, to four millimetres from the point a. Thus the column of air, of 476 millimetres in length, was reduced to four millimetres, which indicates a pressure of 119 atmospheres.



Alcohol may, therefore, be totally reduced to vapour in a space rather less than three times that of its original volume; and at this degree of expansion, it exerts a pressure of 119 atmospheres on the tube which contains it.

The extremities a and f were a little drawn out, in order that they might be more readily closed by the blowpipe; and the capacity of these parts of the tube was ascertained by introduc-

ing a little mercury, which was afterwards passed into the cylindrical part of the tube as a method of measuring it. By this precaution, it was determined, for example, that the length *a a'* of 10 millimetres ought only to be reckoned as two, &c.; the results which have been stated were obtained in this mode.

When the apparatus was cold, a small bubble of gas was observed to have been formed above the alcohol, but it produced a difference of only two millimetres in the level of the mercury in the small tube above *b'*.

In order to determine the degree of heat at which the ether and alcohol are reduced to vapour in these experiments, the tubes containing these fluids were heated in oil, in which a thermometer was placed. A cylindrical glass vessel was employed to contain the oil; by these means it was easy to determine the moment at which the liquids in the tubes were reduced to vapour; it was found that ether required 160°, and the alcohol 207° of Reaumur.

The apparatus above described for determining the pressure exerted by ether and by alcohol, was also subjected to the heat of the oil bath; but a refrigerator was previously adjusted to the upper part of the small tube containing the column of air, by which the temperature of the column was constantly kept at 18°. The results, as to the degree of vaporization and to the pressure exerted, agreed with those which have been described.

When my memoir was read to the Academy, I announced that water heated in glass tubes altered their transparency, so as to prevent any observation of what took place; since that period I have found that, by adding a small quantity of carbonate of soda to the water, the transparency of the glass was much less injured. By this method, I ascertained, although with some difficulty, on account of the frequent breaking of the tubes, that at about the temperature of melting zinc, water may be completely reduced to vapour in a space equal to nearly four times that of its original volume.

Article X.

Analyses of Books.

Transactions of the Royal Geological Society of Cornwall, Vol. II. 1822.

We are happy to introduce to our readers' attention this second volume of the labours of our scientific brethren in Cornwall; the papers it contains are replete with facts that are of much importance, not only in their applicability to practical pur-

poses, but as tending to elucidate some of those more difficult and interesting subjects of geological research, respecting the true nature of which there is such a diversity of opinion. A considerable portion of the volume is occupied by four papers on the temperature of mines, the contents of which we shall not advert to in the present article, as a memoir on the subject will shortly appear in the *Annals*, containing a full account of the facts which are detailed in them. Before we proceed to a brief analysis of the other papers, it may be well to state, from the preface, that the construction of a geological map of Cornwall, intended, according to the wishes of the Society, "to show not only the varieties of rocks, but also the locality and position of the principal metalliferous veins, and the cross-courses which intersect them, has already occupied much of the time and attention of some members;" but this, it is observed, "is an undertaking of immense extent and labour; and the map of the lodes in one parish (St. Just) given in the present volume, will at once show the nature and importance of the plan, as well as the time requisite for the completion of such an undertaking."

I. *On some Advantages which Cornwall possesses for the Study of Geology, and on the Use which may be made of them.* By John Hawkins, Esq. FRS. &c. Hon. Mem. GSC.

The advantages of Cornwall for the study of geology, are stated in this short paper to arise from its being a primitive country, having greater facilities for observation than any inland country can possess; and from the immense extent and importance of its mining concerns. In illustration of some remarks on the vague use of language in this science, the following statement is given.

"It is long since the attention of geologists has been drawn to the disposition observable in every distinct rock mass, to separate in a form which is in some measure characteristic of its composition; although to this day, as far as I know, no general name has been given to this phenomenon. By some who have noticed a degree of uniformity in the angles resulting from the inclination of so many plane surfaces, it has been confounded with crystallization, and by others, on rather better grounds of reasoning, with stratification; although from the first it differs in the very material point of the structure of its mass, which is not one crystal, but an aggregation of crystals; and from the other, in that of continuity. It seems to be the effect of the contraction of matter at the period of its consolidation, and is common both to the volcanic and the Neptunian formations; and this theory derives a further confirmation from the influence which the size and form of the aggregated parts of the mass have in the mode of its division.

"I know of no better generic name for this distinctive character, than that of articulation, while most of its specific forms might be expressed by the terms prismatic, cuneiform, rhom-

boidal, and tabular, of all which we are at no loss for examples in this county."

II. and III. *On the Temperature of Mines.* By Robert W. Fox, Esq. MGSC.

IV. *On the Stratified Deposits of Tin-stone, called Tin-floors, and on the Diffusion of Tin-stone through the Mass of some primitive Rocks.* By J. Hawkins, Esq. FRS. &c. Hon. Mem. GSC.

In Cornwall, Mr. Hawkins observes, the veins of tin are so rich and so numerous, that, with the exception of the alluvial beds of that metal, in the stream-works, every other mode of its deposition in the earth seems to have been disregarded. He then expresses his opinion that the same interest of capital which is obtained by working the tin-lodes, or even a greater, "might be obtained, with infinitely less fluctuation in its amount, from situations where nature has scattered her favours with a more sparing hand, but in a more equal manner:" alluding "to those mineral deposits, which our miners call tin-floors, and more particularly to those important objects of mining industry, which the Saxons call stock-works, should they be found to exist here."

These remarks are succeeded by some information on both these subjects, partly extracted from the author's own journals, and partly from the printed reports of very accurate observers. Tin-floors "are said to occur at Bal-an-uûn, in the parish of Lelant, and at Huel-grouan in the parish of Breage; and, if I am rightly informed," continues the author, "Curclaze mine, near St. Austle, belongs to this class, and merits a very particular examination." The tin-floors on the sea-cliffs of the parish of St. Just are next described; but we shall extract a more particular account of these from a subsequent paper, by Mr. Carne. Such beds are not unfrequent, it is stated, in the highest ridge of the mountains which constitute the boundary line between Saxony and Bohemia. Those at Zinnwald are on one of the highest points on the Bohemian side; "the strata here consist of a fine grained, half decomposed granite, which alternates with the tin-floors. These again consist of quartz, mica, and gneiss," in the two latter of which the tin is found interspersed together with fluor spar and wolfram. "Similar floors, composed of magnetical ironstone, tinstone, and pyrites, occur in other parts of the same range of mountains:" the most considerable of these is situated at Breitenbrunn.

What are called tin-floors at Trewidden Bal mine, in the parish of Madron, in Cornwall, are, correctly speaking, "small, very short fissures or veins, which run partially through the elvan, varying in breadth from half an inch to eight or nine inches, and so irregular and interrupted as to render it difficult to ascertain either their direction or their underlie. These small capricious veins appear frequently to diverge from a central body, and then bear some resemblance in form to the spreading roots of a tree." It is afterwards stated, from another part of the author's journal,

that these floors underlie four feet in six to the north-east, and that they occur in a white porphyritical rock. "The famous Stock-work at Altenberg (a stumbling block in the way of geologists), is nothing else than a large mass of the mountain impregnated with tinstone, occasioned by the meeting of a number of lodes and veins at this point, some of these crossing each other nearly at right angles, some bearing each other along in their crossing, and others stretching along in a parallel or nearly parallel direction. The same natural cause seems to have produced, at the same period, an infinite number of smaller veins and fissures, which run in all directions through the rock, so that many parts of the Stock-work bear a striking resemblance, on a larger scale, to the veined varieties of common marble. The veins here are chiefly of quartz, and are united to the rock in such a manner as to indicate their coeval formation. It is remarkable, however, that the tin lies for the most part dispersed through the latter, and this circumstance has given occasion to the very singular mode of working the mine; for as no profit attended the driving upon regular lodes, and the mass of rock was unequally impregnated with tin, the greatest degree of irregularity appears to have marked the progress of the excavations from their commencement....The rock itself, which composes the Stock-work, is a variety of porphyry, the mass being a fine mixture of chlorite earth and clay, in which the grains of felspar and quartz are scarcely perceptible."

To this follows some particulars of the Stock-work at Geyer, in Saxony; and, after adverting to the probable existence of similar veiniferous masses of rock in Cornwall, Mr. Hawkins concludes his paper with the following advice as to the proper mode of working them.

"I would suggest the expediency of removing the whole mass of impregnated rock from the surface downwards, in successive terraces or levels; most earnestly recommending the immediate adoption of the Saxon process of stamping and dressing. No man who has witnessed this process, can forbear reprobating our own, as rude, wasteful, and inefficient; for if, with any truth, it may be said, that in the art of mining we are inferior to our continental neighbours, we are so in a most shameful degree in the department which I have just mentioned."

V. *On the relative Age of the Veins of Cornwall.* By Joseph Carne, Esq. FRS. MRIA. Hon. MGS. MGSC.

In the commencement of this extended and elaborate communication, after some remarks on the number and variety of the mineral veins of Cornwall, and on the diversity of sentiment respecting the formation of veins, Mr. Carne observes, "with respect to their comparative or relative age, I apprehend all parties (except those who hold that all veins are contemporaneous, and were formed at the same time as the containing rocks), are agreed on this important principle; *that a vein which is inter-*

sected, or traversed, by another vein, is older than the vein by which it is traversed." On this principle, he proceeds, "I would make a humble attempt to ascertain the relative age of the veins of Cornwall."

By a *true vein*, Mr. C. understands "*the mineral contents of a vertical, or inclined fissure, nearly straight, and of indefinite length and depth.*" To the distinctive characters of *contemporaneous veins*, he adds the following: "When these veins meet each other in a cross direction, they do not exhibit the heaves, or interruptions, of true veins, but usually unite. In a multitude of contemporaneous veins, some may appear to be heaved; but the apparent heave seldom affects more than one vein, and it is, in general, easy to perceive that what appear to be separate parts of the same vein, are different veins which terminate at or near the cross vein. When they meet with true veins, they are always traversed by them.

"With all these descriptive particulars, however, it is frequently very difficult to distinguish true from contemporaneous veins;" and, for this reason, Mr. Carne arranges the veins of Cornwall into three orders, of Contemporaneous, Doubtful, and True veins.

The first order comprises veins of the following substances: *Granite in Granite, Felspar, Mica, Shorl, Shorl-rock, Quartz, Actynolite and Thallite, Axinite, Garnet-rock, Prehnite, Chlorite, Ironstone, or Irestone* (compact hornblende, with chlorite and quartz), *Serpentine, Greenstone, Asbestus, Agate, Calcareous Spar in Limestone, Jasper, Opal, and Fluor Spar.*

The second order commences with "*granite veins in slate,*" of which the following account is given: "These have been discovered in no less than fourteen places on the coast of the western part of Cornwall, between Ponthleven and St. Ives Head, viz. (beginning at the most eastern point). 1. About half a mile eastward of Trewavas Head, in the parish of Breage. 2. On the eastern side of Portcue Cove, in the same parish. 3. On the western side of the same Cove. 4. At St. Michael's Mount. 5. At the village of Mousehole. 6. At Rosemodris, three miles south-west of Mousehole. 7. At Carnsilver, about half a mile west of Rosemodris. 8. Near Whitesand Bay, between the Land's End and St. Just. 9. At Porth Just, joining Cape Cornwall in the south. 10. At Polladan Cove, joining the same Cape on the north. 11. At Chycornish Carn, near Botallack. 12. At Pendeen Cove, in St. Just. 13. At Polmear Cove in Zennor. 14. At the Cove north of Zennor church."

"The relative ages of those veins has been a subject of as much discussion as almost any point in geology; especially as it appears to involve several other points, which are deemed, by different parties, of essential consequence to their systems. I believe the more they are examined, the more difficult it will be found to form any consistent theory respecting them: in order,

however, to be convinced of this, it is necessary to examine them at every place where they have been discovered; for so different are their appearance, and attendant circumstances, in different parts, that a very plausible theory made with reference to the veins of one spot only, will be found quite inconsistent with those of another. From the whole, however, the following facts may be collected:

"1. They occur only at, or near, the junction of the granite and slate.

"2. They are not metalliferous.

"3. They have no general direction or position. At Mousehole and Polladan Cove, they run east and west: those at St. Michael's Mount, and some at Porth Just, run west-north-west and east-south-east; those at Polmear Cove, north and south. Some are quite vertical, as at Portcue, Rosemodris, and Polmear Cove: those at St. Michael's Mount and Mousehole are nearly so: others are inclined at different angles, as at Trewavas Head, Porth Just, and Chycornish Carn; and others quite horizontal, as at Polmear Cove: at the latter place, indeed, they may be seen in almost all positions.

"4. Their direction is usually as straight, and their size as regular, as those of true veins; but in some cases, they become smaller as their distance from the granite mass increases.

"5. Their greatest length has never been ascertained: some at Rosemodris may be traced in the slate nearly 200 feet, and are then lost in the sea.

"6. The granite of the veins generally appears different from that of the main body; it is of much smaller grain: it contains a much larger proportion of quartz, and very little mica; sometimes, indeed, no mica at all.

"7. The slate which is contiguous to the veins becomes almost imperceptibly changed from clay-slate to mica-slate, and sometimes has even the appearance of gneiss.

"8. The slate which is close to the veins is frequently much harder than that which is more distant from them, and its texture is, in general, not so slaty.

"9. At St. Michael's Mount, and Polmear Cove, the veins may be traced to the granite mass, with which they appear to be in complete union, and to form one body, losing entirely their character as veins. Whether the other veins unite with the granite mass or not, has not been ascertained, as the point of junction is seldom accessible, or even visible.

"10. At Carn Silver, one of the veins may be traced from the slate *into* the granite mass. This is the only instance which I have discovered of a granite vein penetrating both the slate and the granite.

"11. Some veins (as at Carn Silver, Chycornish Carn, and Pendeen Cove) are closely connected with the slate, and the two bodies appear intimately united, and inseparable: in fact,

they appear contemporaneous. Others (as at Trewavas Head, the western side of Portcue Cove, Rosemodris, and Polmear Cove), are so easily separable from the slate, and have walls so distinct, that, under any other circumstances, they would be taken without hesitation for true veins.

"12. Fragments of slate are visible in several of the veins, as at Trewavas Head, St. Michael's Mount, Mousehole, Porth Just, &c. I have not observed them in the main body of granite.

"13. At Mousehole, and at St. Michael's Mount, the slate is intersected by numerous small quartz veins, some of which are traversed by the granite veins; others, on the contrary, traverse and heave both the granite veins, and the other quartz veins.

"14. At Mousehole, and Whitesand Bay, where a junction of the main bodies of granite and slate takes place, they appear, at some points, so completely intermixed, as almost to exclude any other idea than that of contemporaneous formation; although, at other points, the junction is distinct and regular.

"15. In most other places where the junction occurs, the slate reposes on the granite, without any appearance of a dislocation, or disturbance of the strata, particularly at Portcue Cove, Carn Silver, and Polmear Cove."

After having thus described these curious objects of geological inquiry, Mr. Carne briefly examines the various opinions which have been entertained respecting their origin and formation. He then proceeds to describe the remaining veins of the doubtful order; viz. *veins of steatite, veins of calcareous spar, elvan courses*, and *veins of oxide of tin.*

(To be continued.)

Article XI.

Proceedings of Philosophical Societies.

Royal Society.

Feb. 20.—The reading of a paper, entitled, Experiments on the Velocity and Force of Sound, made at Madras, by John Goldingham, Esq. FRS. was resumed and concluded.

Mr. Goldingham commenced his paper with an account of former experiments, calculations, and assertions, relating to the velocity and force of sound, upon the diversities of which, he stated, the experiments he was about to detail would probably throw some light. He had made some experiments in the years 1793 and 1796, but the results of them had not been published; and more favourable circumstances for the prosecution of the inquiry had since occurred. The experiments and attendant

observations on the subject, which Col. Beaufoy, in the *Annals of Philosophy* for Sept. 1814, had recommended to be made in England, Mr. G. had instituted at Madras.

The observatory at Madras is peculiarly well adapted for the requisite experiments and observations: it is situated in 80° 17′ 21″ E. long. and 13° 4′ 9·1″ N. lat. between Fort St. George and the artillery cantonments at St. Thomas's Mount; being distant from the former 13,932$\frac{1}{3}$ feet, and from the latter 29,547 feet. These distances were determined by a precise measurement, founded on part of Col. Lambton's Trigonometrical Survey.

At the Fort, as is usual in fortified places, a gun is fired morning and evening; in the morning at day-light, and in the evening at eight o'clock; at the artillery cantonments, a gun is fired at sun-rise and at sun-set. The guns are both 24 pounders, are each charged with eight pounds of powder, and are pointed, though not exactly to the observatory, yet very nearly in its direction. The distance of the Mount gun from the observatory being about double that of the Fort gun, a good opportunity was afforded of determining whether sound travels at the same rate through paths of different length.

The observations were made with Arnold's chronometers, usually making 100 beats in 40 seconds; sometimes there were three observers, the author and two Bramin assistants at the observatory, but more commonly there were only two. Each of them began to count on seeing the flash of the gun, and ceased on hearing its report; and then wrote down his observation without communicating it to the other; the observations were afterwards given to Mr. G. for registration. The states of the barometer, thermometer, and hygrometer, the direction of the wind, and the general state of the weather, were noticed at the time of each observation.

Mr. Goldingham gave, in eleven tables, the results of the observations thus made; from which it appears that the mean velocity of sound, by the observations on the Fort gun, is 1142$\frac{18}{100}$ feet per second; and by those in the Mount gun 1142$\frac{5}{10}$ feet; the mean of both series being 1142$\frac{34}{100}$ feet per second: so that the mean rate at which sound travels, as deduced from these observations, is, almost precisely, that which Newton and Halley have assigned.

Mr. Goldingham's observations likewise show that the velocity of sound is considerably affected by the different states of the atmosphere and of the weather, and by the wind, contrary to what has been asserted. The close agreement of the mean velocity by the Mount gun with that by the Fort gun evinces that sound does travel equably through paths of different length. The last table showed the mean velocity at Madras for each month; the velocity increases to a maximum at the middle of

the year, being then 1164 feet per second: the minimum is 1099 feet.

At this meeting, a paper was also read, on the Question as to the Evolution of Heat during the Coagulation of the Blood, by Charles Scudamore, MD. &c. (Communicated by the President.)

A part only of this paper was read, and the remainder postponed to a future meeting.

Feb. 27.—The reading of Dr. Scudamore's paper was resumed and concluded.

In this paper, Dr. Scudamore examined the results as to this subject, which had been obtained by Mr. John Hunter, Dr. J. Davy, and the late Dr. Gordon, of Edinburgh, and expressed his belief that the experiments which he had made upon it would explain the reason of their discrepancies. He then described those experiments; in some of them the successive temperatures of the coagulating blood were compared with those of a solution of starch in water while cooling, and also with those of pure water under the same circumstances; and he inferred from the whole, that a slight evolution of heat does take place during the coagulation of the blood. It commences when the fibrin begins to concrete, but continues throughout the coagulation; in some instances the temperature rose 1°. Some of the discordancies in the statements of former experimenters appear to have arisen from the difference in temperature of different parts of the same portion of coagulating blood.

The following paper was also read at this meeting: On the Double Organs of Generation in the Lamprey, Conger Eel, Common Eel, and Barnacle, which impregnate themselves, and in the Earth Worms, the Individuals of which Class mutually impregnate each other. By Sir Everard Home, Bart. VPRS.

The author of this paper had formerly shown that the teredines were hermaphrodites, subsequently that such also was the nature of the lamprey; and had recently ascertained that the conger and the common eel were similarly characterized. He was inclined to adopt the opinion of the President of the Society, that the last mentioned animals are in reality the same species, their difference in size and colour arising from the circumstance, that the one lives in salt water, and the other in fresh. To determine the fact, an experiment had been instituted by Sir Humphry, and was now going on in Cornwall: young eels, it had been found, soon died in salt-water, but an old one did not appear to suffer any inconvenience in it, and had begun to turn green.

These remarks were succeeded by a particular account of the double organs of generation of the animals mentioned in the title of the paper, and of their mode of copulation, with corrections of the mistakes that former observers had made when examining their anatomy: the species of barnacle examined was the *Lepas anatifera*.

A series of microscopical drawings by Messrs. Bauer and Clift illustrated the details in this paper.

March 6.—On a new Phenomenon of Electromagnetism, by Sir H. Davy, Bart. PRS.

The experiment described in this paper had been first made by the author about fifteen months ago; but had been repeated by him, very recently, through the kindness of Mr. Pepys, with a battery consisting of two plates, each containing 100 square feet, which had been constructed, under the direction of that gentleman, for the London Institution; and of which, Sir Humphry hoped, Mr. Pepys would communicate a description to the Society. The experiment, however, might be made with a pair of plates each containing three or four square feet only.

Sir Humphry had conceived, immediately after the publication of Mr. Faraday's ingenious experiments on electromagnetic rotation, that if mercury could be made to revolve by electromagnetism, some new light might be thrown upon the subject, as the motions of that substance could not be affected by the disadvantages attending mechanical suspension. On immersing, accordingly, the two wires of a battery in mercury, and presenting a magnet to them, either above or below, the mercury was made to revolve around the wires. From the appearance of the motion, Sir Humphry was induced to believe that it could not be owing to any simple action, but that it must be the result of a composition of forces; and that some kind of motion would be produced in mercury by the agency of electricity alone. In order to determine this, he covered the surface of the mercury with weak acids, and with finely divided matter, as the seed of lycopodium, the white oxide of mercury, &c.; but no distinct effects could be observed. It then occurred to him, that, from the circumstances of this experiment, the motion, if any took place, must be chiefly confined to the lower surface of the mercury; and he therefore reversed it. Two copper wires, one-sixth of an inch in diameter, and carefully polished at their extremities, were passed, perpendicularly, through the bottom of a glass basin, and made non-conductors by wax, except at their extremities. Mercury was then poured in, to the height of one-tenth of an inch above the wires, and, upon connecting them with the battery, it was thrown into violent motion, being raised, over the wires, into conical elevations of one-tenth or one-twelfth of an inch, from which waves flowed in all directions. Upon bringing a magnet over the wires, the conical eminences were depressed, the circular motion ceased, and currents were produced in the mercury in opposite directions; and, upon its nearer approach, the eminences were converted into vortical depressions.

That the motion given to the mercury by the agency of electricity, as just described, did not arise from the heat produced, was experimentally determined; when the large battery was

employed, the whole apparatus was converted into a thermometer, and, when the motion commenced, there was no increase of volume in the mercury; nor could the motion have been produced by electric repulsion.

Sir H. Davy would not enter into the conjectural part of the subject any further than to state, that the experiments he had described were unfavourable to the idea, that the phenomena of electromagnetism were produced by the motions of a single fluid; and that the motion communicated to mercury by electric agency seemed to be produced by a fluid, moving either in right lines or in undulations from each wire as a centre. He concluded by observing, that he thought it right to state a circumstance, which, though known to many Fellows of the Royal Society, was not generally understood: this was, that we owe to the sagacity of Dr. Wollaston, the first suggestion of electro-magnetic rotation; and that, had not an experiment on the subject, made by Dr. W. in the laboratory of the Royal Institution, and witnessed by Sir Humphry, failed, merely through an accident which happened to the apparatus, he would have been the discoverer of that phenomenon.

March 13.—On Fluid Chlorine, by M. Faraday, Esq. (Communicated by the President.)

Previous to the year 1810, it had been supposed that the crystals which form in aqueous solutions of chlorine at temperatures below 40° were pure chlorine, but Sir H. Davy then showed that they were an hydrate of that substance. During the late cold weather, Mr. Faraday had made some experiments on this hydrate, and an analysis of it, an account of which will be found in the 15th volume of the Journal of Science; it consists of 27·7 chlorine, and 72·3 water, or, nearly, of one proportion of the former to ten of the latter. The President of the Royal Society suggested, that interesting results might be obtained by examining the decomposition of this compound under pressure, and requested the author to make some experiments on the subject.

Some of the crystals, dried as much as possible by being pressed in bibulous paper, were introduced into a closed glass tube, the open extremity of which was then hermetically sealed. When this tube was immersed in water at the temperature of 60°, no alteration took place in the crystals; but when it was placed in water at 100°, they were decomposed, and two fluids resulted; one of a pale-yellow colour, and apparently water; the other of a deeper greenish yellow; resembling chloride of azote. This did not mix with the water, but when the tube was cooled to 70°, they again crystallized in union. Above the fluids there was an atmosphere of chlorine, the intensity of the colour of which indicated that it was of great density. Upon dividing the tube, a report took place, as of an explosion, the yellow fluid instantly disappeared; and a strong atmosphere of chlorine was produced.

the author at first conceived that the yellow fluid might be a new hydrate of chlorine; but he found that it was also produced by introducing a portion of the gas, dried over sulphuric acid, into a glass tube to which a stop-cock was attached, and then forcing in air by means of a condensing syringe, at the same time applying cold; so that in reality it was *fluid chlorine*.

This fluid may be distilled out of the water by means of a spirit-lamp; at whatever temperature it is produced, it is perfectly limpid and fluid, and it remains so at 0°; it is very volatile; and when exposed at the common pressure of the atmosphere, a portion volatilizes, the remainder being cooled down so low by the evaporation, as to preserve, for a time, its fluidity. By comparing the weights of apparently equal volumes of water and chlorine, the specific gravity of the latter seemed to be 1·33; and that this estimate cannot be far from the truth, the manner in which the chlorine lies in the water is evinced by.

A note had been annexed to this paper by Sir H. Davy, in which he stated, that Mr. Faraday's experiments had induced him to think, that other gases beside chlorine might be reduced to a liquid state by the pressure of their own atmospheres, when evolving from substances containing them; and that, in order to verify this conjecture, he placed sulphuric acid and muriate of ammonia in different parts of a glass tube, and, after sealing the tube, brought them into contact; when an orange-coloured fluid was produced, which was muriatic acid. Although the two substances employed were as pure as they could be obtained, yet the orange-colour of the resulting liquid, he considered, might be owing to iron. Sir Humphry concluded with some remarks upon the superiority which this method of condensing the gases possesses over those of mechanical compression and the application of cold.

LINNEAN SOCIETY.

Feb. 4.—The reading of a paper, on Lansium and other Malayan Plants, by Dr. William Jack, FLS. which had been commenced at the preceding meeting, was resumed and concluded; and the following paper was read: Catalogue of the Land and Freshwater Shells found in the County of Suffolk, by the Rev. Revett Shephard, FLS. Dr. Maton and Mr. Rackett having given the habitats of the land and freshwater shells in the midland and western counties, in vol. viii. of the Linnean Transactions; the purpose of this paper was to supply those of Suffolk and Essex. The author adopted the Linnean arrangement, the genera of which, he was of opinion, were the best for land and freshwater shells; though, at the same time, he expressed his approbation of M. Draparnaud's work, observing that his genera, considering them as subdivisions of the Linnean, were *secundum naturam*.

Feb. 18.—The following papers, by Major-Gen. Hardwicke, FRS. and FLS. were read, all of which were illustrated by

beautiful drawings made by Indian artists:—Description of the *Sciurus sagitta* of Linnæus; Account of the *Buceros galeatus* of Shaw; Description of a new Species of *Phasianus;* Description of the supposed Female of *Phasianus cruentus;* Description of a small *Antelope*, a Native of the Himalaya Range, and of the Mountains in the Nepal Frontiers, called by the Natives *Goral;* Description of an Insect which appears to be a new Species of the *Scutigera* of Latreille, or *Cermatia* of Leach.

March 4.—Description of the Skeleton Head of the long-snouted Alligator of the Ganges, or *Lacerta Gangetica* of Linnæus, presented to the Linnean Society, together with the entire Skeleton of a young Subject of the same Species, by Major.-Gen. Thomas Hardwicke, FRS. &c.

At the same meeting was read, A Description of a Serpent hitherto supposed of the Genus *Boa*, and the *Boa Phrygia* of Shaw.

March 18.—The following papers were read:

Observations on the generic Character of *Locusta*, with the Description of a remarkable Species. By the Rev. Lansdown Guilding, BA. FLS. &c.

The Natural History of *Phasma ramulus*. By the same.

Observations on the Genus *Asalaphus*, with the Description of a new Species. By the same.

On the Nature of the Marine Production commonly called *Flustra arenosa;* considered by Ellis and Gmelin as belonging to the Order Vermes Zoophyta; but rather to be considered as the Matrix of *Nerita glaucina*, by John Hogg, Esq. BA. FLS. St. Peter's College, Cambridge.

Description of the Taile Bat, by Major-Gen. Hardwicke.

Description of *Fuveræa agavephylla*, the *Agave Cubensis* of Linnæus and Jacquin, and the *A. Mexicana* of Lamarck, by M. Felix de Avelear Protero, Prof. Bot. Coimb.

On the Generic and Specific Characters of the *Chrysanthemum Indicum* of Linnæus, and of the Plants called Chinese Chrysanthemums, by Joseph Sabine, FRS. FLS. &c.

GEOLOGICAL SOCIETY.

Jan. 3.—A paper was read, on the Beds of Limestone and Clay of the Ironsand of Sussex, by Gideon Mantell, Esq. MGS. and Charles Lyell, Esq. MGS.

Mr. Mantell traces the direction of the calcareous beds connected with the ironsand formation in the county of Sussex, and enumerates their several localities; to which he subjoins drawings and descriptions of some of the most remarkable fossils found in the limestone of Tilgate Forest. He then adds a letter addressed to him by Mr. Lyell, containing an account of the strata in the neighbourhood of Horsham, with a section of the quarry of Stammerham, and with remarks on the phenomena presented by the grooved and furrowed surfaces both of the calcareous and sandstone beds of that country.

A Notice was then read, accompanied with Specimens, by Charles Daubeny, MD. FRS. and MGS. Professor of Chemistry at Oxford, illustrative of the Strata cut through in the Seven Rakes Mine, near Matlock, Derbyshire.

After describing the qualities of the strata of limestone and toadstone, their dimensions and connexions with each other, and the minerals which they contain, both in veins and regularly disseminated through the mass; Dr. Daubeny concludes with general observations on the phenomena which they present. He considers that there would be great difficulty in reconciling the facts there observed with that theory which refers to an igneous origin the formation of the toadstone.

Feb. 21.—Two letters were read, communicated by the President, addressed by Joseph Byerly, Esq. to B. Fayle, Esq. containing some notices on the Geology of Sierra Leone.

At Sierra Leone and in the immediate neighbourhood, sienite, porphyry, and basalt, are the predominant rocks.

Feb. 21 and *March* 7.—A paper was read, entitled, "Notes on the Geography and Geology of Lake Huron, including a Description, accompanied by Drawings, of new Species of Organic Remains," by John Bigsby, MD. MGS.

In this paper, the author enters in some detail into a geographical and geological description of the coast and islands of Lake Huron in North America. The greater part of the northern shore is composed of primitive rocks; while the Manitoulline islands which stretch nearly across the centre of the lake, with the southern coast, are entirely composed of secondary calcareous formations. To this paper is subjoined a map of Lake Huron, and plates illustrative of the organic remains which are contained in great abundance in the limestone rocks.

March 21.—A paper was read, entitled, "Observations on the Belemnite," by J. S. Miller, Esq. ALS. communicated by the Rev. W. D. Conybeare, MGS.

The author commences this paper with an historical sketch of the various opinions which have been entertained with regard to the belemnite, and of the works of those naturalists who have treated of that fossil. He enumerates the various names which ignorance or superstition assigned to it in the earlier periods; and, lastly, the almost equally discordant and imperfect theories which have been successively advanced on the same subject by writers of a more recent date. Mr. Miller then offers his own opinion on the original structure and nature of this organic body, and adds the reasons and the experiments which have led him to his conclusions. He considers the belemnite to have been an animal of the Cephalopodous division of the mollusca, inhabiting a fibrous spathose conical shell, divided into chambers connected by a siphunculus, and beyond which shell extended a protecting guard or sheath. Mr. Miller refers the internal radiated texture to its original organic structure, and not to any subsequent process of crystallization. To this paper is

subjoined an enumeration and description of the various species of belemnites, accompanied by plates illustrative of their form and structure.

ASTRONOMICAL SOCIETY.

The Third Anniversary Meeting of this new association, which is rapidly advancing in importance and prosperity, was held at the Society's Apartments, No. 55, Lincoln's Inn Fields, on Friday the 14th of February last. At this meeting, a report from the Council was read, stating, among other matters, that the Society now consisted of 187 effective members and associates, including the greater number of the eminent astronomers of Europe; that the funds were in a flourishing condition; and that great progress had been made in establishing an astronomical library, which would shortly be opened for the use of the members. A just tribute of respect to the memory of the lamented President of the Society, was likewise paid in this report, as well as to those of Sir Henry Englefield, Dr. Hutton, M. Delambre, M. Tralles, and several other valuable members, of whom the Society had been deprived by death during the past year; and it concluded by calling upon the members and associates, generally, to promote the objects of the Institution by every means in their power, and particularly by the transmission to the Society of such papers and observations as might become useful by their registry and comparison. A minute investigation of the heavens was also recommended to be effected by dividing them into small portions, each to be examined by an individual member.

The following officers were then elected for the ensuing year:

President.—Henry Thomas Colebrooke, Esq. FRS. and FLS.

Vice-Presidents.—Francis Baily, Esq. FRS. and FLS.; Major Thomas Colby, Roy. Eng. LLD. FRSL. and E.; Davies Gilbert, Esq. VPRS. and FLS.; Sir Benjamin Hobhouse, Bart. FRS.

Treasurer.—Rev. William Pearson, LLD. FRS.

Secretaries.—Charles Babbage, Esq. MA. FRSL. and E.; John Millington, Esq. MGS. Prof. Mech. Phil. Roy. Inst.

Foreign Secretary.—J. F. W. Herschel, Esq. MA. FRSL. and E.

Council.—Capt. F. Beaufort, RN. FRS.; George Dollond, Esq. FRS.; Benjamin Gompertz, Esq. FRS.; Stephen Groombridge, Esq. FRS.; James Horsburgh, Esq. FRS.; Daniel Moore, Esq. FRS. FSA. and FLS.; Peter M. Roget, MD. FRS.; Major-Gen. John Rowley, Roy. Eng. FRS.

March 14.—Several new members were proposed, and others elected. A considerable number of astronomical books were presented to the library of the Society; and two papers were read. The first was a demonstration by means of a functional equation, of the result of two forces acting upon a particle of matter; communicated by Dr. Miekleham, late Professor of Astronomy in the University of Glasgow. The second was

entitled, "On the Results of Computations relative to the Parallax of α Lyræ from Observations made with the Greenwich Mural Circle, compared with those of Dublin; by Dr. Brinkley, Prof. of Astronomy, Trin. Col. Dublin:" this was a highly interesting paper.

Article XII.

Scientific Intelligence, and Notices of Subjects connected with Science.

I. *Mr. Faraday's Liquefaction of the Gases.*

We have already described, at p. 304, in our report of the proceedings of the Royal Society, the means by which Mr. Faraday has succeeded in reducing chlorine to the liquid state; and we are happy to announce that he has also succeeded, by analogous modes of operation, in liquefying the following aëriform substances: euchlorine, nitrous oxide, sulphurous acid, sulphuretted hydrogen, carbonic acid, and cyanogen. All the liquids thus produced are colourless, with the exception of euchlorine; and all are perfectly fluid, and highly volatile.

II. *Re-opening of Mr. Sowerby's Museum.*

We feel much satisfaction in announcing that the late Mr. Sowerby's Museum of the Natural Productions of Great Britain, at No. 2, Mead-place, Lambeth, is again opened for the inspection of his friends and the lovers of natural history, every Tuesday from eleven till four o'clock, under the direction of his sons and executors, James de Carle Sowerby, FLS. and Charles Edward Sowerby.

III. *Prof. Daubeny on Rocks that contain Magnesia.*

Dr. Daubeny having withdrawn his paper on this subject from the Royal Society, in the hope of its appearing at some future time, in a more complete state, has requested us to correct two mistakes in our report of it, published in the *Annals* for February, p. 150.

We have there represented Dr. D. as saying, that the presence of magnesia in the oolites "has not been ascertained with certainty;" whereas, he states, there are several specimens of them in the catalogue at the end of his paper, which are mentioned as containing that earth. In the second place, Dr. Daubeny observes, we have transferred to his mode of separating lime from magnesia, the objections which he had alleged against preceding methods, and from which he imagines his own to be exempt; "for it will be seen by reference to my paper in the Edinburgh Philosophical Journal," he continues, "that the difficulty of driving off the ammoniacal salts and water originally present, without at the same time decomposing the magnesian sulphate, was my inducement for substituting that scheme of analysis which is inserted in the *Annals*, the peculiarity of which consists in its enabling the operator to calculate the quantity of magnesia by merely ascertaining the amount of the sulphate of lime obtained, deducing from thence that of the lime, and comparing the result with the quantity taken up originally by the acetic acid."

IV. *On the Question as to the Existence of Metallic Veins in the Transition Limestone of Plymouth.* By Mr. Prideaux, and the Rev. Richard Hennah.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Plymouth, Feb.* 15, 1823.

Observing some doubts expressed in your last number of the accuracy of Mr. Hennah's statement, that our "lime rocks contain no metallic veins;" I am induced to offer you some reasons for coinciding fully in his opinion.

I believe I speak much within compass in saying, that the face of that rock is open to an extent of above four miles; and that more than half of it has been in regular work within the last five years. For nearly the whole of this extent we get to the upper surface, and in several different places we trace its repose on, and alternation with, the clay slate, for a considerable distance. The cliffs and quarries are from 50 to 150 feet high, and cut the strata at all angles. And the limestone itself forms only the hilly boundary of the sea, nine-tenths of it being exposed.

I think, therefore, it is almost impossible that a metallic vein, however minute, existing in it, should have escaped detection.

The specimen you describe, as found at Cat-Down, looks like a fact in opposition to this conclusion; but I have several times traced the whole course of the extensive quarries in that situation from top to bottom (though my opportunities are not so frequent as Mr. Hennah's); and although varieties of crystallization, and not metallic specimens, were my pursuit, the latter could hardly have escaped me; nor have the men employed in the quarries ever mentioned such appearances in my hearing.

That the mines of Tavistock yield specimens of crystallized carbonate of lime, bearing abundant marks of their metallic connexion, and much like the one in question, you are doubtless aware. I should hardly suppose, therefore, that you could have been deceived in it, though the little mineral dealers here are likely enough to make the mistake. But the considerations above related appear to me so decisive that were I to find a detached specimen, such as you describe, at Cat-Down, any where but *in situ*, I could not believe it to be the produce of those quarries, where I have seen nothing to which it appears at all related. I am, Sir, your most obedient,

John Prideaux.

SIR, *Citadel, Plymouth, March* 8, 1823.

I perused, a few days ago, in the 26th number of the *Annals of Philosophy,* a quotation from a recent publication of mine, on the "Lime Rocks of Plymouth," in which I state that it is my opinion, that they contain *no metallic veins,* which quotation is accompanied with an account of a particular specimen of quartz, &c. making part of a collection said to be from our quarries; and with a suggestion, that the circumstance merited further inquiry. Being myself desirous to promote any investigation, which has for its object the correction of any error which I may have inadvertently fallen into, or the establishment of any point which I believe to be true, I hope your correspon-

dent will excuse me for requesting you to permit me, through the same medium, to express my doubts as to the accuracy of his information respecting *the place* from whence the specimen he so minutely describes originally came.

First, I would ask, whether he himself met with the specimen in question at the quarry? If so, in which of the quarries was it found? As there are many at Cat-Down, all of which I have frequently and carefully examined, without ever finding in them, or in any others, from the Dock Yard to the Ferry House at Cat-Down, *quartz in mass*, independent of galena, and the other substances composing the stone.

Secondly, if your correspondent did not find the specimen himself, but purchased it with others, I would beg of him to compare it with such as he *knows to be the legitimate produce of our lime rocks;* and I think he cannot fail of remarking the great dissimilarity, if not the total want of any *family likeness* between them. And then let him reflect how little dependance is to be placed on the veracity of those who generally have such articles for sale; and whose duplicity, art, or ignorance, I have daily opportunities of detecting.

I would further state, that I have in my possession a specimen so similar to the one above-mentioned, that I should almost be tempted to say, that both came from the same place. Mine is certainly from one of the mines in the vicinity of Tavistock, where the mixture of quartz, galena, &c. &c. is frequent and often curious.

I will only add my sanguine expectation that this will meet with a candid reception, and an early place in your *Annals*, and conclude in the last words of my own publication; "that it will give me real pleasure at all times to receive any information from others, whose personal knowledge and actual researches may enable them to throw any new light on the subject of these pages."

I remain, Sir, your obedient servant,

RICHARD HENNAH.

*** The Editor is enabled to state, in reply to the foregoing letters, and in order that the question to which they relate may be decided, that the small specimen described in the notice on the subject, inserted in the *Annals* for February last, was purchased in the latter part of September, 1822, with specimens of limestone and of stalactite unquestionably obtained from the Plymouth rocks, of Edmund Moss, quarryman, at Cat-Down. The author of the notice certainly has not mistaken *calcareous spar* for *quartz*, as a paragraph in Mr. Prideaux's letter implies him to have done.

V. *On the Depression of the Barometer in Dec.* 1821. By Mr. A. Edwin.

The following observations on the extraordinary depression of the barometer in Dec. 1821, were made in Owen's-row, near Islington, by Mr. A. Edwin; and have been communicated by him, in compliance with the request of Prof. Brandes, inserted in the *Annals* for October last. The basin of the barometer is situated about 40 feet above the bed of the New River, which runs before the house.

On Dec. 11, the barometer was at 30·13 inches, and thence gradually descended, with some slight intermediate elevations, until it fell to 28·74 inches on the 24th at 8 a.m.

1821.	Time of observation.	Barom.	Ther. (out).	Wind.	Strength.	R a.	Weather.
Dec. 24	8 a. m.	28·74	43	SW	Smart gusts.	—	Cloudy and showery; a gale, with heavy rain between 6 and 7 a. m.
	5 p. m.	28·21	44	SE	Brisk.	—	A faint rainbow appeared at 10 a. m.
	8½ p. m.	28·07	—	—	Strong gusts.	1·164	Cloudy, with gentle rain; 6 to 8 p. m. a gale, with very heavy rain.
	11 p. m.	27·93	47	—	Brisk.	—	Cloudy, with steady rain till midnight.
25	12½ a. m.	27·88	47	—	Calm.	—	Cloudy and mild.
	1 a. m.	27·87	46½	—	Ditto.	—	Ditto.
	2 a. m.	27·87	46½	—	Ditto.	—	Ditto.
	3½ a. m.	27·86	—	—	Ditto.	—	A few stars appeared in the SE.
	4 a. m.	27·84	—	—	Ditto.	—	Cloudy.
	5 a. m.	27·84	—	NW	Smart gusts.	0·041	Cloudy, with heavy showers of rain.
	6 a. m.	27·90	—	—	Ditto.	—	Cloudy, with heavy rain; 7, cloudy.
	8 a. m.	28·01	39	NW	Ditto.	—	Cloudy.
	5 p. m.	28·33	39	W	Gentle.	—	Clear.
	11 p. m.	28·42	33	—	—	—	Very clear.
26	8 a. m.	28·32	35	E	—	—	Cloudy.
	5 p. m.	28·27	40½	E	Gentle.	0·353	Cloudy, with gentle rain; wet afternoon.
	11 p. m.	28·38	32½	—	Brisk.	—	Clear.
27	8 a. m.	28·76	37	W	Gentle.	—	Chiefly cloudy.
	5 p. m.	28·85	41	SW	Strong gusts.	0·325	Cloudy, with steady rain; heavy showers of hail and rain at 11 a. m. and 4 p. m.
	11 p. m.	28·90	40½	—	Brisk.	—	Cloudy.
28	8 a. m.	28·71	41½	S	Smart gusts.	—	Chiefly clear.
	5 p. m.	28·15	46	S	—	0·595	Cloudy and showery; a heavy gale, with rain and sleet at 2 p. m.
	11 p. m.	28·07	45½	—	Very brisk.	—	Cloudy; a heavy shower of rain.
29	8 a. m.	28·07	43	NW	Brisk.	—	Cloudy.
	5 p. m.	28·48	45	W	Strong gusts.	0·155	Cloudy.
	11 p. m.	28·71	45½	—	—	—	Cloudy, with steady rain.
30	11 p. m.	29·38	36	N	Very brisk.	0·113	Very clear; stars remarkably bright and numerous.
3	11 p. m.	29·79	33	NW	Gentle.	—	Partially cloudy, with a light fog.

The mean height of the barometer for the month was 29·212 in. and that of the thermometer 43·290°.

VI. *Alkohometrical Application of the Thermometer.*

In the *Annals* for October last (p. 395), we gave an account of M. Groening's discovery on this subject; and we now present a tabular view of the results of his experiments:

Spirits of wine holding, according to Tralle's alcohometer at a temperature of 60° Fahrenheit.	Temperature of the boiling liquid, according to Fahrenheit.	Temperature of the vapours, according to Fahrenheit.
Per cent. of alcohol.		
95°	173·18°	170·37°
90	174·31	171·5
85	174·87	172·06
80	175·46	172·63
75	176·56	173·75
70	177·71	174·87
65	178·83	176·0
60	179·40	176·56
55	179·97	177·12
50	181·62	178·83
45	182·19	179·40
40	183·31	180·5
35	185·0	—
30	187·25	185·0
25	189·50	187·25
20	192·40	190·62
15	195·77	194·0
10	200·84	199·06
5	205·30	204·12
0	212·0	210·0

VII. *Account of a new Mineral, named Chloropal.*

Prof. Bernhardi, of Erfurt, and Dr. Rudolph Brandes, have given the description and analysis of a new mineral, which they call Chloropal, and of which they distinguish two varieties, the conchoidal and the earthy.

It occurs not far from Unghwar, in the Comitate of the same name, and had received the trivial name of green iron earth. The conchoidal variety is pistachio-green, the powder yellowish-white; it is scarcely translucid on the edges, fracture conchoidal, hardness between fluor and calcareous spar, fragile; its specific gravity, according to the mean result of different experiments, approaches very nearly to 2,000. The parallelopiped fragments into which it is apt to break have on the face which, in their natural place, has been turned upwards, a positive magnetic pole; on its lower face a negative. Four other poles occur on the lateral edges, of which two adjoining are positive, and two opposite negative. The mineral has, therefore, three magnetical axes, which pass each other at right angles, and agrees in that respect with opal; but is quite different from quartz and other similar minerals: it does not phosphoresce.

The earthy variety has the same magnetic properties as the former; its fracture is earthy; its specific gravity 1,870; that of another piece 1,727. Both occur with opal.

The composition of the conchoidal chloropal is:

Silica	46·0
Oxide of iron	35·3
Magnesia	2·0
Alumina	1·0
Potash and manganese	Traces
Water	18·0
	100·0

The earthy chloropal contains:

Silica	45·0
Oxide of iron	32·0
Magnesia	2·0
Alumina	0·75
Potash and manganese	Traces
Water	20·0
	99·75

Experiments were made to discover fluoric acid, sulphuric acid, lime, and potash, but none was found.

VIII. *On the Galvanic Ignition of Charcoal.* By Mr. W. West.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Leeds, Feb,* 1823.

In the *Annals of Philosophy* for Aug. 1822, there appeared a communication from Dr. Hare, of Philadelphia, to the Editor, containing an account of various interesting phenomena produced by means of his galvanic deflagrator: one of these is the ignition of charcoal.

Dr. Silliman, in a letter quoted in the above communication, after describing the appearance of the charcoal at the respective poles, the cone and deposit at the positive, the concavity at the negative, goes on to state as a discovery his having observed these appearances, and adds, "I deem it indispensable that the experiments be performed with the deflagrator."

About twelve months since, when exhibiting the ignition of charcoal before the members of the Philosophical Society here, I was struck with the effect on the charcoal being so opposite at the two poles; the crater on the negative side being well defined, and about one-eighth of an inch deep, the cone on the positive charcoal corresponding, and having at its apex a filament which continued lengthening until broken off by its own weight. I pointed out this in my lecture, but though, as far as I recollect, it had not then been mentioned in any work, I imagined all who had observed the ignition of charcoal with a powerful battery must have seen the same effects produced. I have since repeated the experiment several times, and have verified most of the particulars mentioned by Dr. Silliman; I think that the vapour arising from the charcoal is more abundant when the ignition takes place in vacuo than when in the atmosphere.

I wish to observe more accurately than Dr. Silliman appears to have done, whether there be an increase of weight after ignition in the charcoal at the positive pole; but having little prospect of leisure at pre-

sent, I take this mode of calling attention to the subject, since some who would be likely to pursue it might be discouraged by Dr. Silliman's statement of the inefficacy of the common battery.

The subject is curious and highly interesting, since it involves the following questions:

Is the charcoal fused?

Is it vaporized?

Is it transferred from the one pole to the other, and, if so, in what manner?

Would not satisfactory answers to these questions throw much light on many abstruse points, and especially on that most difficult question in physics, the relation of radiant, or empyreal, or imponderable bodies to ordinary matter? WILLIAM WEST.

IX. *On a Mineralogical Work of Agricola, &c.* By G. Cumberland, Esq. Hon. Mem. GS.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Bristol, Dec.* 9, 1823.

Your correspondent, Mr. Conybeare, at p. 366 of the *Annals* for Nov. 1822, in his analysis of the work of Vannoccio Biringuccio, asks from what work of Georgio Agricola he relates "the discovery of a mass of silver ore, in one of the Saxon mines, sufficiently large to make a table and a seat, or stool (tripode)." In return for the satisfaction his paper has afforded me, I have the pleasure to inform him that Vannoccio found it in a dialogue, entitled "Il Bermanno," in compliment to his friend Bermanno, the physician; placed at the end of Agricola's treatise "On the Generation of Things underground, with their Nature and the Nature of Fossils;" the other interlocutors being Nicola Ancone and Giovanni Nevio. In this dialogue we have a very minute account and history of the mines near Friberg, in Bohemia, one of the richest in silver of which, was, according to his statement, that called Georges, from St. George (as may be seen leaf 404, for the book is so paged). At leaf 446, on the blank side, Bermanno states, that pure masses of silver are only found in Bohemia.

In Sneberg, in a mine called Georgio, more is found, he observes, than in all the other mines in Germany, for (as he has heard) there was once so large a mass extracted, that Duke Albert of Saxony, who, above all other princes of Germany, excelled in glory, arms, and wealth, and who was the father of that Georgio who now is the sovereign Prince, having stopped to see the mines, and called for some refreshment, made use of that great mass of silver for his table, and those who attended him, and had likewise dismounted; and during his repast, he observed, "the Emperor Frederick is powerful and rich, but he cannot sit down to-day at such a table as this!" These, says he, were the words of the Duke Albert, astonished greatly at this prodigious mass of pure silver; "but I was more astonished," continues Bermanno, "when in Sneberg I heard a calculation of the amount of silver it had produced." To which Nevio replies, "You tell us things very uncommon; pray what might that mass weigh?" and Barmanno answers, "A little more than (x mipeso) ten thousand pounds.

This dialogue consists of forty-seven leaves, the first of which is numbered 520, instead of 420, is really very interesting, and is

written in pure and elegant Italian; being a translation from the Latin of the author. It has a preface by Michael Tramezzino, the printer in Venice, 1550. Georgio Agricola states at leaf 421, that his motives for having entered so copiously into the study of metals, was their utility in the practice of the Greek and Roman physicians, of the fruits of which he modestly leaves others to judge, referring for testimonials to Bartolomeo Baccho and Lorenzo Bermanno, men of letters, as well as expert metallurgists, whom he has often, he says, wearied with his inquiries.

During the dialogue, they ascend to the mining country, and while examining the operations of the mines, discuss many interesting subjects relative to the acquaintance of the ancients with the nature of metals, and to the uses to which they applied them in medicine; also respecting the nature of plumbagine, pyrites, red silver ore, earths of various colours, minium, cinnabar, rubrica, spars, gypsum, &c.

In Froben's Folio, 1563, of Agricola's Arte Metalli, translated from the Latin into Italian by Michelangelo Florio, of Florence, and by him dedicated to Queen Elizabeth of England, there is another dedication of the work, by Agricola himself, to the Duke of Saxony, in which, after recapitulating all that Greek and Latin authors have written on the subject, he adds, "In our language, I find two only; one relating to experiments on ores and metals, which work is very obscure, and its author unknown; the other on mineral veins, which is said to have for its author, Pandolfo, an Englishman." Query, who was this Pandolfo? A book in German also, he says, was written by Calbo Fribergo, a physician of but little reputation; and all these, it should seem, wrote previously to Vannoccio Birenguccio; but of him he speaks so handsomely, that you will permit me to give it in his own words:

"Poco ha iziandio che Vannoccio Biringuccio da Siena, *homo dotto & isperimentato in molte cose*, fece un libro in lingua Italiana, nel quale tra trattato del modo di fondere, spartire, et *congiugnere* insieme i metalli. Ha eziandio con brevità trattato del modo di cuocere alcune vene et pue chiaramēte ha dichiavato e mostrato il modo de fare alcuni sughi: e quando. Io lessi queste sui cose, mi ternaron a mente quei che gia vidi fare in Italia: ma l'altre cose che io scrivo, o egli non l'ha punto toeche a legiermente;" adding, that the book was given him by Badoaro, a noble Venetian, when passing through Marienburg as Ambassador to King Ferdinand. Might not, therefore, this work be interesting to English artists, if carefully translated?

I am, Sir, yours, &c.

G. Cumberland.

Article XIII.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

Dr. Pring, of Bath, will shortly publish an Exposition of the Principles of Pathology.

Capt. Franklin's Narrative of his Journey from Hudson Bay to the

Copper Mine River, is in the Press. It will be illustrated by numerous Plates.

Mr. Bowdich has in the press, a Sketch of the Portuguese Establishment in Congo, Angola, and Benguela, with some Account of the modern Discoveries in the Interior of Angola and Mosambique.

JUST PUBLISHED.

An Epitome of the Elementary Principles of Natural and Experimental Philosophy; including Mechanics, Pneumatics, Acoustics, Hydrostatics, and Hydraulics: with a copious Account of the Progress and present State of the Steam Engine. By John Millington, MGS. Professor of Mechanics at the Royal Institution, Secretary to the Astronomical Society, &c. &c. 1 Vol. 8vo. with 14 Plates. The author announces a Second Part, which is to treat of Magnetism, Electricity, Optics, and Astronomy.

A Geometrical System of Conic Sections for the Use of Mathematical Students at the Royal Liverpool Institution. 8vo. 6*s*. 6*d*.

Elements of Practical Mechanics. By Giuseppe Venturoli, Professor of Mathematics in the University of Bologne. To which is added, a Treatise upon the Principles of Virtual Velocity, and its Uses in Mechanics. Translated from the Italian, by Daniel Cresswick, DD. Fellow of Trinity College, Cambridge. 8vo. 8*s*.

Observations on the Effects of Lightning on Floating Bodies, with an Account of the new Method of applying fixed and continuous Conductors of Electricity to the Masts of Ships. In a Letter to Vice-Admiral Sir Thomas Byam Martin, Comptroller of his Majesty's Navy, &c. &c. By W. Snow Harris, MRCS. 4to. With Six Plates. 12*s*.

An Essay on the Medicinal Efficacy and Employment of the Bath Waters; illustrated by Remarks on the Physiology and Pathology of the Animal Frame, with Reference to the Treatment of Gout, Rheumatism, Palsy, and Eruptive Diseases. By Edward Barlow, MD. Graduate of the University of Edinburgh, and one of the Physicians of the Bath Hospital, &c. 8vo. 8*s*.

Digitalium Monographia, sistens Historiam Botanicam Generis; tabulis Omnium Speciarum hactenus cognitarum illustratam, ut plurimum confutis ad Icones F. Bauer, penes G. Cattley Arm. cure J. Lindley, FLS. et FHS. Folio. With 28 Plates, 4*l*. 4*s*. Coloured, 6*l*. 6*s*.

The Natural History of the Lepidopterous Insects of New South Wales. Collected, engraved, and faithfully painted after Nature, by J. W. Lewin, ALS. late of Paramatta, New South Wales. 4to. With 19 Plates, 1*l*. 11*s*. 6*d*.; or finely coloured, 2*l*. 8*s*.

The Birds of New South Wales, and their Natural History. By the same Author. 4to. With 26 Plates, 2*s*. 2*s*.; or coloured, 6*l*. 6*s*.

The Linnean System of Conchology, describing the Orders, Genera, and Species of Shells, arranged into Divisions and Families, with a View to facilitate the Student's Attainment of the Science. By John Mawe. With 36 Plates. Plain and coloured Frontispiece, 1*l*. 1*s*.; or the whole beautifully coloured, 2*l*. 12*s*. 6*d*.

An Account of some recent Discoveries, Hieroglyphical Literature, and Egyptian Antiquities; including the Author's original Alphabet, as extended by Mr. Champollion; with a Translation of five published Greek and Egyptian Manuscripts. By Thomas Young, MD. FRS. &c. With Plates. 8vo. 7*s*. 6*d*.

A Statistical and Commercial History of the Kingdom of Guatimala, in Spanish America; containing important Particulars relative to its Productions, Manufactures, Customs, &c.; with an Account of its Conquest by the Spaniards, and a Narrative of the principal Events down to the present Time. From original Records in the Archives, actual Observation, and other authentic Sources. By Don Domingo Juarros. Translated by J. Baily, Lieut. Roy. Mar. Illustrated with Maps. 16*s*.

Columbia; being a Geographical, Statistical, Agricultural, Commercial, and Political Account of that Country; adapted for the general Reader, the Merchant, and the Colonist. With a Map, and Portraits of Bolivar and Zea. 2 Vols. 8vo. 1*l*. 16*s*.

Article XIV.

NEW PATENTS.

G. Richards, of Truro, Cornwall, architect, for certain improvements in grates, stoves, furnaces, and other inventions; for the consumption of fuel, and in the flues connected with them, whereby they are rendered more safe, and the smoke prevented from returning into the rooms in which they are placed; and also, for an improved apparatus for cleansing the same.—Dec. 26.

T. Rogers, of Store-street, Bedford-square, Middlesex, Esq. for a method or apparatus for the purpose of attaching trowsers and gaiters to boots and shoes.—Dec. 26.

J. Neville, of New-walk, Shad Thames, Surrey, civil engineer, for an improved method of producing and applying heat to, and constructing and erecting furnaces and other reservoirs, severally used for the various purposes of roasting or smelting metallic ores, or other substances, and likewise for effecting a saving in fuel, and producing a more complete combustion of smoke than at present takes place, as well as a better mode than any now in use, of collecting and preserving any volatile substance contained in, or combined with, metallic ores or other substances in the separation of which heat is necessary.—Jan. 8, 1823.

W. Johnson, of Great Totham, Essex, Gent. for a means of obtaining the power of steam for the use of steam-engines with reduced expenditure of fuel.—Jan. 8.

W. Lister, of Baildon, Otley, Yorkshire, cotton-spinner, for certain improvements in the method and machinery for preparing and spinning wool, silk, mohair, and other animal fibre, of any quality or length of staple.—Jan. 16.

R. Copland, of Wilmington-square, Clerkenwell, Middlesex, Gent. for combinations of apparatus for gaining power; part of which are improvements upon a patent already obtained by him for a new or improved method or methods of gaining power, by new or improved combinations of apparatus applicable to various purposes.—Jan. 16.

G. Miller, of Lincoln's Inn, Middlesex, Brevet Lieut.-Col. in the Royal Brigade, for a method or plan of communicating the spiral motion to shot and shells when fired from plain barrels, and for igniting, by percussion, shells to which the spiral motion has been thus communicated.—Jan. 16.

Article XV.

METEOROLOGICAL TABLE.

1823.	Wind.	Barometer. Max.	Barometer. Min.	Thermometer. Max.	Thermometer. Min.	Evap.	Rain.	Daniell's hyg. at noon.
2d Mon.								
Feb. 1	N E	28·97	28·75	40	36	—	99	
2	N E	29·00	28·75	42	39	—	15	
3	N E	29·40	29·00	45	30	—	25	
4	Var.	29·80	29·40	37	27	—		
5	E	29·80	29·75	34	27	—		
6	E	29·75	29·35	34	27	—	—	
7	E	29·58	29·35	44	30	—	61	
8	W	29·82	29·58	44	33	—		
9	W	29·82	29·62	44	37	—	11	
10	S W	29·62	29·60	45	34	—	38	
11	S W	29·60	29·50	52	42	—	03	
12	S W	29·73	29·50	50	40	—	01	
13	W	29·73	29·57	45	37	—		
14	W	30·00	29·57	48	33	—		
15	N W	30·30	30·10	40	34	—	12	
16	N E	30·30	30·30	40	32	—	—	
17	N E	30·30	29·91	38	30	—	—	
18	N W	29·91	29·27	45	38	—	28	
19	W	29·96	29·27	47	30	—		
20	N W	29·96	29·72	46	34	—	01	
21	N W	29·72	29·68	49	39	—	—	
22	S W	29·80	29·68	46	34	—	40	
23	S W	29·80	29·65	46	41	—	43	
24	N W	29·80	29·79	48	34	—		
25	S	29·79	29·24	48	33	—	10	
26	W	29·24	29·10	45	27	—		
27	N	29·53	29·13	42	31	—	—	
28	N W	30·05	29·53	42	30	·96		
		30·30	28·75	52	27	·96	2·92	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Second Month.—1—3. Rain. 4, 5. Fine. 6. Snow began about two, p. m. 7. Rain. 8, 9. Fine. 10—12. Rain. 13. Fine. 14. Rain: some hail in the afternoon. 15. Rain. 16, 17. Cloudy. 18. Fine morning: rain in the evening. 19. Fine day: very wet and stormy night. 20. Very fine: a distinct lunar halo in the evening. 21. Overcast. 22. Rainy. 23. Heavy rain: a violent driving shower of hail, which continued for about one minute, when it abated a little: night very boisterous. 24. Cloudy. 25. Rain: overcast. 26. Cloudy and fine. 27. Fine: a little snow, p. m. 28. Fine.

RESULTS.

Winds: N, 1; NE, 5; E, 3; S, 1; SW, 5; W, 6; NW, 6; Var. 1.

Barometer: Mean height

For the month.. 29·620 inches.

For the lunar period, ending the 2d .... 29·774

For 14 days, ending the 12th (moon south) .... 29·437

For 13 days, ending the 25th (moon north) .... 29·812

Thermometer: Mean height

For the month.. 38·660°

For the lunar period.................................... 30·224

For 29 days, the sun in Aquarius..................... 36·034

Evaporation.. 0·96 in.

Rain.. 2·92

Laboratory, Stratford, Third Month, 24, 1823. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

MAY, 1823.

Article I.

Additional Remarks on the Rothe Todte Liegende and Weiss Liegende of German Geologists. By Thomas Weaver, Esq. MRIA. MRDS. MWS. MGS.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Tortworth, April* 4, 1823.

In my former papers, I endeavoured to elucidate the subject of the rothetodtliegende formation, as well as that of the weissliegende, in such a manner as might obviate all further misconception or doubt;* not by gratuitous assumption, but by strict induction from the observations and descriptions of those who have best studied the subject in Germany; at the head of whom stands Freiesleben. In conducting this discussion, it has been my object constantly to bear in mind that the solution of a problem cannot be valid, unless it embrace all the conditions necessarily belonging to it; nor the sense of an author be justly given, unless the scope of his argument be fully considered in all its branches and bearings. Partial views generally lead to false results. Yet it seems I have failed in conveying conviction where I particularly wished to impress it.† Nor is it difficult to account for the failure, since my opponent persists in attaching a meaning to the word rothetodtliegende, for which I confess I can find no adequate German authority. However averse to

* See *Annals of Philosophy*, Oct. and Nov. 1821, and Aug. 1822.

† See the interesting "Memoir illustrative of a general Geological Map of Europe, by the Rev. W. D. Conybeare," in the *Annals of Philosophy* for Jan. Feb. and March, 1823.

controversy, a desire of supporting and vindicating the true state of the case, impels me once more to resume the pen.

Mr. Conybeare insists that the rothetodtliegende is the equivalent of the calcareous or new conglomerate of England, overlying the carboniferous series; and he even contends that Freiesleben considers and treats the rothetodtliegende and the true coal formation as appertaining to two different series; adding, that the invariable order in ascending is, 1. Coal formation. 2. Porphyry. 3. Rothetodtliegende; and sections are quoted from Keferstein, as demonstrative of this position.

I have already stated that the great object of Freiesleben's extended work was the description of the four following groups, or formations; opposite to which I place their English equivalents. They are considered in four sections:

I. The upper or shell limestone formation................	Lias and oolitic series.
II. The upper, or newer, or variegated, sandstone formation....................	New red sandstone formation.
III. The lower or alpine limestone formation, including the *weissliegende* as the lowest bed..................	Magnesian limestone formation, including the *calcareous* or *new conglomerate* as the lowest bed.
IV. The lower or older sandstone, or rothetodtliegende, formation................	Carboniferous series.

I have maintained that the weissliegende alone (and not the rothetodtliegende) is the representative of the calcareous or new conglomerate of England.* The general description of the new conglomerate is to be found in the *Annals of Philosophy* for November, 1821, and more at large in Freiesleben, vol. iii. p. 239—280. It is to that author the Germans owe the clear exposition of the true character of the weissliegende, and the proof that it belongs to a newer series than the carboniferous; while almost all preceding German writers had considered the weissliegende as the uppermost bed of that series, and included it accordingly, and some even had called it rothliegende. But to continue so to apply the latter denomination is obviously to persevere in an antiquated error, exploded by Freiesleben. And conversely, to

* I purposely avoid using in this paper the term "new red conglomerate or sandstone," by which this formation has been partly designated in England; since it has led, and, if continued, is likely still to lead to misconception. As used by some English writers, it denotes the calcareous conglomerate; sometimes it includes the magnesian limestone, and sometimes it is extended to the new red sandstone formation also, properly so called. A vagueness of language thus arises, which is productive of considerable obscurity; offering nearly a counterpart to that which has proceeded from the indiscriminate use of the term rothetodtliegende in Germany, as applied to all parts of the carboniferous series.

call the true rothetodtliegende the new conglomerate, and then to build on this misapplication of the term, is a sure method to render a subject, otherwise simple and clear, involved and confused; and thus calculated to mislead both the writer and reader, confirming the remark of Bacon, that "while men believe their reason governs their words; it often happens, that words have power enough to react upon reason."

I have maintained that the rothetodtliegende formation is the equivalent of the carboniferous series, extending from the old red sandstone to the coal formation inclusive, or *vice versâ*. Now to prove that Freiesleben's own view of the matter is identical with that which I have given, I think it will be sufficient, in addition to the facts detailed in my former papers, to transcribe in this place the Synoptical Table of that author, prefixed to his fourth volume, which exhibits the method according to which he considers and treats this subject; and then to offer a few remarks intermingled with such illustrative extracts from the body of the work, as bear more immediately on the question.

"SECT. IV.—*The Lower Sandstone Formation, or Rothe Todte Liegende.* Die Untere Sandstein Formation (das Rothe Todte Liegende).

Occupying pages 67—210 of the fourth volume, and considered under the following heads:

I. *The Rothe Liegende* (*Red Sandstone*) *separately considered.* Das Rothe Liegende an und für sich betrachtet, p. 73—137.

Beds composing the Rothliegende, viz. *conglomerate, breccia, sandstone, slaty micaceous sandstone, indurated slaty clay,* and *clay marl*, p. 73—99.

Structure, p. 99—107.

Relative position, affinities, and *graduations*, p. 107—118.

Intermingled minerals, including also *beds of limestone*, compact splintery, sub-lamellar, or granular, p. 118—123.

Distribution of ferruginous matter, p. 123—127.

Veins in the rothliegende, p. 127—131.

Petrifactions, p. 131—136.

Springs and mineral waters, p. 136, 137.

II. *The Subordinate Members.* Untergeordnete Gebirgsarten, p. 137—191.

1. Porphyry and amygdaloid, p. 137—147.
2. Coaly shale, p. 147—169.
3. Coal, 170—191.

Distinctions hitherto made respecting the relation of the coal formation to that of the rothliegende, p. 170—172.

Occurrence of coal, 172—191.

In Sangerhausen, p. 173—175.

In Stollberg, 175—178.

In Anhalt Bernburg at Opperode, &c. and in the Circle of the Saale, 179.

With this Synoptical Table for a guide, and Freiesleben's descriptions in illustration, it has been a great surprise to me that any one should ever have doubted that the older sandstone, or rothetodtliegende formation of the Germans, was the representative of the carboniferous series.*

After the details into which I have formerly entered, the more immediate remarks required on the preceding synoptical table may be confined, *first*, to the rothliegende separately considered; and *secondly*, to the nature of its connexion with the coal formation.

1. Now with respect to the *rothliegende considered separately*,

* It may be useful in this place to refer to the origin of the expression rothetodtliegende, or *red dead lier*. It has been applied to the carboniferous series in general for this reason; that in some quarters the coal formation associated with red sandstone as one of its members; in others, the old red sandstone itself (both more or less strongly characterised by the diffusion of red oxide of iron), form the immediate support of the weissliegende or new conglomerate, and bituminous marl shale, the two former thus acting in relation to the two latter as the *red dead lier*; that is, as the red substratum, comparatively barren of metal, in contradistinction to the superincumbent new conglomerate and bituminous marl shale, both of which are abundantly metalliferous.

I may here repeat the remark, which I made in a former paper (*Annals of Philosophy*, January, 1823), that the expressions todtliegende, rothliegende, and rothetodtliegende, are synonymous, the two former being frequently employed for the sake of brevity.

if we pay due attention to its *physical characters*, and to its *relative position*, *affinities*, and *graduations*, I know not how it is possible to resist the evidence thus afforded, that it represents, in its *lowest position*, the old red sandstone of English geologists.

The *general characters* of the beds composing the rothliegende as consisting of *conglomerate*, *breccia*, *sandstone*, *slaty micaceous sandstone*, *indurated slaty clay*, and *clay marl*, have been given in the *Annals of Philosophy* for Aug. 1822, p. 84—86; and I there adverted to their agreement with those of the old red sandstone of Gloucestershire (and of the adjoining counties), and also of that of Ireland. But no where is the analogy to be found more complete in all its parts than in the old red sandstone of Scotland, particularly that portion of it which borders the northern side of the Scotch great coal tract.* I know no other portion of the carboniferous series, with which the rothliegende in its lowest position can be said to correspond so perfectly.

With regard to the *relative position* and *affinities* of the rothliegende, the following extracts from Freiesleben may suffice.

Vol. iv. p. 107, et seq. "The rothliegende is always bounded on the one side by one or the other member of the cupriferous shale tract, lying generally immediately below the calcareous or new conglomerate (weissliegende) or the cupriferous marl shale; but its confines on the other side are less determinate. Here it graduates principally into tracts of greywacke and clayslate, or porphyry, accordingly as it reposes upon, or forms basins in, one or the other of them."†

"In several districts, its immediate lower boundary is formed by one or the other of these tracts; but in some others a formation of coaly shale or coal is found interposed between them."‡

* See Dr. Boué's instructive description of the *poudingues et grès rouges* of Scotland, p. 102—119, of the Essai Géologique sur l'Ecosse; and compare it with Freiesleben's description of the *rothliegende*, vol. iv. p. 73—137. The two descriptions agree so perfectly as to answer nearly one for the other.

† To render the above paragraph perfectly clear to the English reader, it is necessary to bear in mind that the *red sandstone* of the coal tracts of Germany, bears the name of rothliegende as well as the fundamental portion of the carboniferous series, namely, the old red sandstone. In point of position, the former might be partly compared to the red sandstone found in some of the English coal fields, which, appearing at intervals, sometimes forms beds of great thickness and extent, dividing the more common coal bearing strata from each other, and partly known by the name of *pennant stone*, e. g. in the Gloucestershire south coal field. It is one of the peculiarities of several of the coal fields in the north of Germany, that coarse red conglomerate and red sandstone are found frequently alternating on a greater or smaller scale with the other coal measures, the former partly resembling analogous beds in the fundamental old red sandstone. This is particularly observable in Lower Silesia, where a bed of coarse red conglomerate generally forms the immediate roof of the coal seams; a bed of slate clay of seven feet in thickness being there a rare occurrence. See Von Buch, Geog. Beob. vol. i p. 90 and 101. Also Freiesleben's description of the Opperode and Petersberge coal districts as quoted by me in the *Annals of Philosophy*, August, 1822, p. 87—89; and Von Raumer in the *Annals of Philosophy*, Oct. 1821, p. 248—250, and Aug. 1822, p. 91—93.

‡ This observation requires attention, and will be duly noticed hereafter, p. 329.

"Generally speaking, the rothliegende seems the more disposed to receive foreign ingredients into its composition, as well as beds, the nearer it approaches to the fundamental rocks upon which it reposes. And it is not to be denied that *it possesses many points of agreement with transition tracts;* so much so, that some geologists are disposed to rank it rather with the transition series, and to commence the floetz series only with the rocks peculiarly belonging to the bituminous or cupriferous marl shale" * (of which the weissliegende, or new conglomerate, is the first or lowest member).

The connexion of the rothliegende with transition greywacke and clayslate tracts, is exemplified by a reference to the districts of Mannsfeld, Sangerhausen, and Stollberg, where it reposes upon, and partly graduates into them.

Its connexion with porphyry (trap also occurring in the association), is stated to be particularly well exhibited in the Forest of Thuringia, the two formations not only alternating with, but appearing in a manner diffused in each other; e. g. in the northern declivity of the Schneekopf, and again extending from the Grossen Buche into the Schmückengraben in the same mountain. Its intimate alliance with porphyry is shown also in Mannsfeld.—(See *Annals of Philosophy*, Aug. 1822, p. 87.)

In all these cases, the ingredients which compose the rothliegende are said to vary more or less according to the constitution of the transition or primary tracts upon which it reposes.—(See Freiesleben, vol. i. p. 32—34, and p. 43—46; and also vol. iv. p. 67—99.)

Both relative position and physical characters, therefore, prove that the rothliegende constitutes, in *its lowest position,* the fundamental portion of the series, or what is designated in England as the old red sandstone.

2. The same inference is to be drawn, from considering the *connexion of the rothliegende with the coal formation.*

On this subject, Freiesleben (see p. 170—172 of vol. iv.) adverts, in the first place, to the distinctions formerly made in Germany respecting the relation of the coal formation to the rothliegende; some writers having considered a portion only of the coal formation as included in the rothliegende, while others incorporated the whole of the coal formation with the rothliegende; thus constituting, instead of *one group with two divisions, one simple unbroken series.* As an exemplification of the latter mode of considering the subject, he produces the arrangement of Karsten, who gives the following beds as a type of the general series, taken in an ascending order:

† "See Von Hoff in Leonhard's Taschenbuch. Jahrgang. viii."

1. Conglomerate of ancient rocks. 2. Siliceous conglomerate. 3 to 8. Coal, sandstone, and shale. 9. Trap rocks. 10. Clay ironstone. 11. Rothliegende. 12. Weissliegende.	All comprehended in one general group, entitled the *older sandstone,* or *rothetodtliegende formation.**

Now what is the observation of Freiesleben upon this series? He says it is too general, and not sufficiently distinct, and, therefore, for the sake of greater clearness and precision, he considers it necessary to *describe* the rothliegende and the coal formation under *separate heads;* and he arranges the subject accordingly, as displayed in the synoptical table, leaving for his third and last division the account of the occurrence and distribution of the series in general.

It is obvious from the structure of that table, that *coal* is considered by him in a *general point of view* as a *member* of the *older sandstone or rothetodtliegende series;* and so far he continues to adhere to the arrangement of his predecessors. But he qualifies this general view by a more particular one, expressed in the following words: "I have throughout my present exposition considered the rothliegende and the true coal tracts (eigentliche steinkohlengebirge, with siliceous conglomerate, slate-clay, and bituminous shale), as *two very closely allied formations, but which ought nevertheless to be distinguished from each other.* And hence in my descriptions I always make a distinction between the *true coal tracts,* and *those single beds of coal* that occur incidentally subordinate to the rothliegende."† This particular

* The series given above is also quoted by Mr. Conybeare, on which that gentleman observes, "If we look among these rocks for the representative of our own old red sandstone, it must be sought in No. 1 and 2, not in No. 11;" an observation in which I perfectly agree with him, since it is one of the points for which I have been contending; in confirmation of which I have to observe, that No. 1 and 2 of that series do in fact represent the *lowest portion* of the rothliegende of Freiesleben.

But that Karsten's group is to be considered as a general type of the older sandstone series, and not as expressing with precision the order of succession throughout, appears evident from the introduction of trap rocks and clay ironstone under Nos. 9 and 10. The two principal members of the series are first expressed, namely, the old red sandstone by No. 1 and 2, and the coal formation by No. 3 to 8. Then trap and clay ironstone are noticed, the former as being incidental both to the old red sandstone and to the coal formation, and the latter as more peculiarly belonging to the coal formation. With respect to the rothliegende, No. 11, I must repeat that it is in this position a term, denoting the upper portion of the coal measures, where interstratified with and divided by *red sandstone* on a greater or smaller scale as one of its members. And lastly, with regard to the weissliegende No. 12, I must also repeat that this formation had been considered as the uppermost bed of the older sandstone series by most German writers, until Freiesleben demonstrated that it was the lowest member of the succeeding alpine limestone formation (answering to the English magnesian limestone), thus corresponding with the calcareous or new conglomerate of England.

† I give the original passage in this place. "In meiner gegenwärtigen darstellung habe ich jederzeit die formation des rothliegenden und die eigentlichen steinkohlenge-

view, however, does not invalidate his general position; namely, that all the true coal tracts are comprehended in the older sandstone or rothetodtliegende series; an arrangement in which all German geologists have always concurred. This state of the case is proved, not only by the synoptical table, but by the words of the author's text, from which I subjoin the following extracts:

Vol. iv. p. 179. "It is quite certain that the bed of coal near Opperode, in Anhalt, *lies in* the rothliegende, and I must affirm the same of the coal near Wettin, both from my own observations, and from the accounts of others, that may safely be relied on. But of these I need take no further notice in this place, as I mean to describe them in distinct dissertations in the second appendix to this volume."

I have given the substance of these descriptions in the *Annals of Philosophy*, Aug. 1822, p. 87—89, to which I beg leave to refer the reader; and in relation to which I will here only add two other extracts.

Vol. iv. p. 194. "The rothliegende extends from Hettstädt eastward beyond the river Saale;" and "nearer toward Wettin its *outcrop is covered by the coal tract* (näher nach Wettin zu, wird *sein ausgehendes von steinkohlengebirge bedeckt*)." And p. 123, where the same fact is related in the following words: "I have been assured that beds of oolitic limestone have been met with in the *rothliegende that lies below the Wettin coal seams.*" This language, than which none can be more explicit, is quite consistent with that of Lehman, who speaks of the rothliegende as "*la base sur laquelle sont appuyés les lits du charbon de terre,*" and which I quoted upon a former occasion.*

Again, vol. iv. p. 208. "The coal tracts (steinkohlengebirge) situated near Beuthen, Pleiss, and Troppau, in Upper Silesia, near Schweidnitz, in Lower Silesia, and in the south-western and north-eastern portions of the county of Glatz, are likewise ascribed by Von Buch, as well as by later writers, to the formation of the todtliegende.† The todtliegende, however, appears in many parts of those countries *in its usual form;* that is, destitute of coal." The same fact is repeated, p. 190, 191, with the addition, "Reuss likewise states, that considerable beds of coal

birge (mit kieselconglomerat, schieferthon, und brandschiefer), *als zwey, einander zwar ganz nahe stehende, aber dennoch von einander zu trennende formationen*, betrachtet; daher ich auch immer noch einen unterschied zwischen dem weiterhin zu beschreibenden (untergeordneten) vorkommen *einzelner steinkohlenfloetze* im rothliegenden und zwischen dem *eigentlichen steinkohlengebirge* annehme."

* I avail myself of this opportunity to notice an oversight committed in transcribing the account of the lower coal field near Wettin (not Löbegün, as stated by Mr. Conybeare), by having inserted "rothe todtliegende," instead of "rothes thonartiges liegendes," as the lowest bed (No. 16) observed in that coal field. The error, however, is of no real importance, since the expression signifying an argillaceous bed of the rothliegende, it amounts to the same thing.

† "Von Buch. Mineralogical Description of Landeck."

occur in the todtliegende in Bohemia." * And the same observation is to be found in vol. i. p. 46.†

Yet with all these facts before him, Mr. Conybeare assures us, "that the plan of Freiesleben's work does not extend to the coal formation, properly so called." And why? Because that author has made a distinction between the single beds of coal that occur incidentally subordinate to the rothliegende, and the continuous coal tracts. With equal justice might it be said, that the plan of a writer on the north-east of England did not extend to the coal formation, properly so called, because a distinction was made between the single beds of coal incidentally disposed in the carboniferous limestone of that tract, and the continuous coal measures.

I think it needless to repeat in this place what I have already stated in former communications concerning the occasional juxta-position of the old red sandstone and the coal formation, as well as concerning their association with limestone, porphyry, and trap, respectively.

There is, however, one part of the German description (adverted to above, p. 325) that requires distinct notice, since from the language employed, it has probably given rise to considerable misapprehension. It is where it is said, that a formation of coaly shale or coal is interposed in some districts between the rothliegende and the subjacent tracts of clayslate and greywacke, or porphyry; particularly in certain parts of the Forest of Thuringia. This representation seems to imply nothing more than that, in the general expanse of the carboniferous series, a part of the coal formation is itself in particular quarters in contact with transition or primary tracts. Yet, even in these cases, rothliegende is said to form the basis of the coaly shale or coal. See e. g. the account of the coaly shale near Goldlauter, in the Upper Trogberg, near Breitenbach, and other places, which indeed are considered by Von Hoff and Jacob as belonging to the coal formation (Freiesleben, vol. iv. p. 142—169). See also the local occurrences of coal in various parts of the Forest. (Ib. p. 179—191.) In several of these cases, both limestone and porphyry are associated in the series.

The preceding references and extracts from Freiesleben have, I conceive, clearly proved, that the rothetodtliegende series of the Germans is the representative of the carboniferous series of the English. And no where can I find any evidence in that author, by which it could be shown, that the rothetodtliegende series has any connexion beyond that of juxta-position with the weissliegende; a formation, which, corresponding both in physical characters and in relative position with the calcareous or

* "Reuss. Mineralogische und Bergmännische Bemerkungen über Böhmen."

† In stating that Von Buch and Reuss refer the true coal tracts of Silesia and Bohemia to the todtliegende formation, it is the intention of Freiesleben to show that they belong to the first floetz or carboniferous series, in contradistinction to formations of coal of later origin (e. g. wood coal) also found in those countries.

new conglomerate of England, can alone be considered as forming the first member of the succeeding series; namely, of the gypseous and saliferous. The weissliegende, however, has, as already remarked, been sometimes called rothliegende by some German writers, and this misapplication of the term has thus also led to a confusion in description, which really does not exist in nature. And here, perhaps, Mr. Conybeare may find one of the sources of the misconception into which he has fallen.

From all that has been stated, it is evident that Freiesleben affords no support whatever to the position of my opponent; namely, that the rothetodtliegende is the equivalent of the calcareous or new conglomerate of England; and that which is attempted to be derived from the sections of Keferstein must, for the same reasons, appear invalid. The order noticed there in ascending is, it seems, 1. Coal formation; 2. Porphyry; 3. Rothliegende; 4. Alpine, or lower limestone formation; 5. New red sandstone.*

Upon this section I have to observe, in the first place, that the weissliegende or new conglomerate being by Freiesleben included in the alpine or lower limestone formation, I presume it is so included in No. 4 of this section; and consequently that the rothliegende No. 3 cannot be intended by Keferstein to be its representative. And, in the second place, Freiesleben having clearly shown the porphyry and coal to be comprehended in his general rothliegende series, the term rothliegende applies to the uppermost beds of the coal formation as well as to the lowest bed of the carboniferous series.† To exhibit, therefore, the coal formation, porphyry, and rothliegende, in the above order, as a type of the general series, is manifestly an imperfect mode of representing their mutual relations; since the rothliegende (as has been shown from Freiesleben) is found alternating with porphyry below the coal formation, and the coal formation itself occurs also alternating with porphyry. The fact appears to be that in the section adverted to above, Nos. 5 and 4 (the latter of which comprehends also the new conglomerate as the lowest member) constitute together the saliferous and gypseous series; while Nos. 3, 2, and 1, belong to the carboniferous series, yet displayed in a manner that, so far from being luminous, conveys only an imperfect idea of the general subject. Of the two, the series presented by Karsten, though by no means complete (and from which the weissliegende must be excluded), is, as a general type of the rothetodtliegende formation, superior to that of Keferstein. Hasty generalizations and forced constructions, instead of promoting, tend rather to retard the progress of

* I quote from Mr. Conybeare, not having myself yet seen Keferstein's memoirs. I presume these memoirs are compiled rather from the recorded observations of others than from original researches conducted by that author himself.

† See the preceding remarks and notes on this head.

science; and correct approximations can only be produced by close comparisons, and a careful attention to those details that are but too often overlooked.

Mr. Conybeare has promised to produce detailed quotations from Lehman, Karsten, Von Buch, Von Humboldt, Freiesleben, Von Raumer, D'Aubuisson, and Keferstein (I place these names nearly in chronological order), all of which shall concur in proving, that the *great mass of the rothetodtliegende* occupies a position superior to the coal measures. Now, supposing even that this were the case, it could be of no avail to the argument of my opponent, as rothetodtliegende does not signify the new conglomerate. It is doubtless owing to such a prepossession in the mind of that gentleman, that he has ventured to assert that the whole of the rothliegende (with its beds of limestone and porphyry), extending from the Hartz to the Petersberge on the Banks of the Saale, is in a position superior to the coal formation. I must, however, take the liberty of observing, that this statement appears wholly unjustified, being *an inversion of the fact*, and decidedly at variance with the detailed descriptions and general scope of Freiesleben's work.

My opponent seems to have been misled, and to have adopted this notion, partly by misconceiving the true import of a term, and partly by taking an imperfect view of the series connected with the coal in the Ihlefeld, Opperode, and Petersberge districts. In the first of these, which ranges to the south-east past Neustadt, the constituent members appear (so far as they are exposed) arranged in the following ascending order:*

1. Coarse grained rothliegende, becoming gradually finer.
2. Fine grained rothliegende.
3. Common indurated clay.
4. Floor shale.
5. *Coal*, divided by intervening shale into three layers, 10, 8, and 6 inches thick respectively, forming altogether a seam 30 inches thick.
6. Roof shale.

The roof shale and floor shale, as well as that which divides the coal seam, contain impressions of ferns and reeds.

7. Thin slaty indurated clay.
8. Trap, for a short distance, which is partly amygdaloidal.
9. Porphyry, extensively, in abrupt cliffs, and in mountain masses.
10. Rothliegende.

The real purport of the term rothliegende in this series has been already explained; and I need here only add, that the group (being succeeded by the weissliegende or new conglomerate, and the cupriferous marl shale), gradually thins off to the eastward, until in the district of Questenberg, the weissliegende

* See Freiesleben, vol. iv. p. 175—178, and also p. 146, 147; likewise vol. i. p. 43, 44.

comes in direct contact with the transition tract; so that in fact there is no visible connexion between the carboniferous rocks of Ihlefeld and Neustadt, and the old red sandstone which, proceeding from the Stollberg territory, ranges through Sangerhausen and Mannsfeld, and thence to the Banks of the Saale. But supposing a connexion to subsist between them (which is not improbable), though concealed by the newer floetz formations; if we take into account the disposition of the rocks of Ihlefeld and Neustadt, the range being north-west and south-east, and the dip south-west, and conceive them to be prolonged in the line of their south-eastern direction; it becomes evident, that they must be all in a position superior to the old red sandstone of Sangerhausen and Mannsfeld, yet belong nevertheless to the same series. On the other hand, the coal formation at Opperode appears, from the description of Freiesleben, to extend eastward to Meisdorf, and, perhaps, as far as Endorf, if not further, and to repose in that direction on the old red sandstone, which in its progress to the westward gradually thins off. The relative position of the Petersberge coal tract has been already clearly explained. For its description, as well as that of Opperode, see the *Annals of Philosophy*, Aug. 1822, p. 87—89.

Let us now admit my opponent's construction of Freiesleben, *in the tract extending from the Hartz to the Petersberge on the Banks of the Saale*, taken in a descending order, and see to what it leads:

1. The rothliegende is the new conglomerate. It is covered by the weissliegende or calcareous conglomerate.

N. B. From this it would appear as if the German series possessed a supernumerary new conglomerate.*

2. The rothliegende contains beds of porphyry, also beds of limestone, also *single* beds of coal.

N. B. Impressions of monocotyledonous plants, considered as characteristic of the true coal formation, appear in this association.

3. The whole of these are in a position superior to the coal formation, properly so called, which belongs to a different series.

4. The plan of Freiesleben's work does not extend to the coal formation, properly so called.

N. B. Yet the plan of Freiesleben's work does extend to the transition tracts, upon which the rothliegende, in its lowest position, is described as reposing, and into which it in a manner graduates. Therefore, if we were to combine these two views, the carboniferous series would seem to be excluded from the geological succession altogether. Yet it is admitted that

* The *general* character of the weissliegende is that of a *calcareous* conglomerate, but it not unfrequently appears as a *siliceous* conglomerate. Hence, though *sufficiently distinguished by other characters*, it has been sometimes confounded with the rothliegende.

5. True coal formations do occur in the districts of Ihlefeld, Opperode, and Petersberge; beside those which are found in Upper Saxony, Silesia, Bohemia, Thüringerwald, &c.

Now if we are to consider the coal formation, properly so called, and the carboniferous series in general, as excluded from the plan of Freiesleben's work (and as a necessary consequence from the works of Von Buch, Reuss, Von Raumer, &c. also); I should wish to be informed in what book or books, and in what specific form of words, any description of the carboniferous series of Germany is to be met with?

Contrast these inconsistencies with the following simple view of Freiesleben, *extending from the Hartz to the Banks of the Saale*, taken in an ascending order, and for the abstracted details of which I refer to the descriptions given in the *Annals of Philosophy*, Aug. 1822, p. 83—91.

1. The rothliegende, *in its lowest position*, reposes on the transition tracts, into which it graduates in a manner.

N. B. It thus represents the *old red sandstone* of the English.

2. The rothliegende contains incidentally *single* beds of coal, also beds of limestone, and beds of porphyry.

N. B. Impressions of monocotyledonous plants occur in association with the coal.

3. The preceding form the basis of the coal formation, properly so called.

4. The coal formation, properly so called, consists of the usual coal measures, which alternate with beds of porphyry, and beds of *rothliegende* of greater or less extent (the latter being the *red sandstone of the higher position*).

N. B. This *red sandstone* of the higher position is *exclusively* designated by Mr. Conybeare as the rothetodtliegende, and as the first member of the saliferous series, in direct opposition to the general language of Freiesleben. The remains of monocotyledonous plants occur in the above association; whereas those of dicotyledonous plants appear in the gypseous and saliferous series.

All the preceding constitute together the older sandstone, or rothetodtliegende, formation or series.

5. The weissliegende, or new conglomerate, overlies the rothetodtliegende series, from which it is wholly distinct, forming the first member of the gypseous and saliferous series. It contains no formation of coal, nor any formation of porphyry.*

I think it needless to pursue this subject further; persuaded that the explanations already given of the expressions "the older sandstone, or rothetodtliegende formation," on the one hand, and the "weissliegende" on the other, may supersede

* The new conglomerate of England also contains no formation of coal, and probably none of porphyry either. I have given my reasons, on a former occasion, for suggesting that the conglomerate and sandstone associated with amygdaloidal trap in Devonshire, may be referable to a much earlier era.—(See *Annals of Philosophy*, Aug. 1822, p. 94.)

the necessity of further comment. Nor should I have been drawn thus far into controversy, had I not considered the exact determination of the question to be of primary importance, in ascertaining the true relations of a portion of the structure of the earth.

Since, however, the term rothetodtliegende formation has been productive of so much misapprehension in the minds of foreigners,* I venture to suggest to German geologists the expediency of abstaining from the use of it altogether. By whatever means a more perfect harmony might be established between the British and German descriptions, it could not fail to redound to the advantage of science. This object might be readily attained if German writers, adopting in part the language of English geologists, would for the future express the group by the term "first floetz, or carboniferous series," instead of "rothetodtliegende formation," and the individual members (*whenever circumstances will admit of the distinct division*) by those of "old red sandstone, carboniferous limestone, and coal formation."† And, in like manner, both countries might speak the same language if the succeeding group were designated by the expression "second floetz, or gypseous and saliferous series," and its individual members by those of "calcareous conglomerate, lower alpine or gypseous limestone, and new red sandstone, formations."

I shall close this paper by adverting to a few remarks contained in the memoir of Mr. Conybeare, referred to above, which require notice, being connected with the present question.

1. My information respecting the Portishead case was derived from the "order of superposition of strata" of Prof. Buckland, appended to Phillips's Outlines of the Geology of England and Wales, 1818. I find that Mr. Greenough also rested on the same authority, when stating that imperfect coal in thin beds occurred in the lower part of the old red sandstone (See group, No. 22, of the Geological Map of England and Wales). But the position being now retracted, the quotation becomes of course invalid.

2. It is stated by Mr. Conybeare, that "the coal seams which occur in the tract of the carboniferous limestone are reduced to slight traces, which have never yet been worked."

This statement does not correspond with the representation

* E. g. Omalius d'Halloy, who has erroneously applied the term rothetodtliegende to conglomerates belonging to the gypseous and saliferous series.—(See that author's Geological View of the adjacent Parts of France and the Netherlands, in the 24th vol. of the Journal des Mines.)

† Von Raumer, in his description of the carboniferous series of Lower Silesia, the county of Glatz, and part of Bohemia and Upper Lusatia, avoids the expressions rothliegende, todtliegende, and rothetodtliegende altogether; designating the general series by the term "the red sandstone (rother sandstein) formation."—(See the *Annals of Philosophy*, Oct. 1821, and Aug. 1822.)

of Dr. Boué in Scotland, from which it appears that the greater number of the Scotch collieries are situated in that portion of the tract which abounds in limestone.*

According to that author, the carboniferous series, designated by him under the general term of *terrain du grès rouge*, or *la grande formation de grès rouge*,† appears to be arranged in the following order in the great coal tract of Scotland:

1. Old red sandstone.	Poudingues et grès rouges (in a restrictive sense).‡
2. Coal formation.	Grès houiller, divided into
a. Lower portion.	Assises inférieures.
b. Upper portion.	Assises supérieures.
c. Uppermost portion.	Assises les plus supérieures.

The *old red sandstone*, as the foundation of the whole, contains beds of trap and felspar rocks (partly porphyritic and amygdaloidal), with which it also alternates, and likewise some beds of limestone.

The *lower portion* of the *coal formation* is characterised by an inconsiderable quantity of coal, by variable masses of anthracite, by beds of trap and felspar rocks (partly porphyritic and amygdaloidal), by beds of limestone, and by sandstone that is sometimes of a *reddish* hue.

In the *upper portion* of the *coal formation*, the trap beds seem gradually to disappear, and then follows only a *fine series of coal measures*, associated with numerous alternating *beds of limestone*. It is in this portion of the coal tract that the greatest number of the Scotch collieries are situated.

The *uppermost portion* of the *coal formation* is distinguished by the absence of beds of limestone, by its abundance of coal and of vegetable impressions, and by the appearance of shells resembling freshwater species. This portion of the tract, which most nearly agrees in its general relations with the great coal fields of England, is, however, of rare occurrence in Scotland, and appears to be confined to certain parts of Clackmannanshire, and the environs of Falkirk and St. Andrew's. Of the Clackmannanshire coal fields, a very able account has been given by Mr. Bald in the Wernerian Memoirs.

Dr. Boué dwells in particular ou the numerous beds of limestone that are distributed throughout the greater portion of the Scotch collieries, and on the few localities in the coal tract in which that mineral is found wanting.§

* I have briefly referred to Dr. Boué's account of the coal fields of Scotland in my Comparative View in the *Annals of Philosophy*, Oct. 1821, and again in Aug. 1822.

† See Essai Géologique sur l'Ecosse, p. 98—102; also p. 163, 362, 371, &c.

‡ See its description, p. 102—119 of the Essai Géologique sur l'Ecosse.

§ It was, I presume, from observing the intimate state of association prevailing among the different members of the carboniferous series in Scotland (the extreme fundamental part only being free from coal, and the extreme highest part only being destitute of limestone), that Prof. Jameson was induced to follow the German method by ranging the

It is important both to the landed proprietor and the miner to know, that valuable seams of coal do sometimes occur within the domain of the carboniferous limestone; and in Scotland, it is manifest that the limestone and coal are frequently found in alternation. Nor is the carboniferous limestone of the north-east of England wholly free from them, as shown in Mr. Winch's valuable paper in the fourth volume of the Geological Transactions.*

I have upon former occasions adduced these and other examples to show, that though a general order may be every where perceived in the arrangement of the carboniferous series, yet that this order is subject to variation *in detail* in different countries, and even in the same tract of country. Now, it being established that in some countries the carboniferous limestone is productive of valuable seams of coal; if it happen in another country, that the carboniferous limestone is almost or entirely wanting, and the old red sandstone and coal formation are thus found in a state of juxta-position, why should it be thought

whole under one great head, entitled "the first floetz sandstone, or *old red sandstone* formation."* Applied in this manner, the expression is equivalent to that of the "old or first floetz sandstone, or *rothetodtliegende* formation," of the Germans, and to the "first floetz series," or "carboniferous series," of English geologists. These collective terms, like the "grande formation de grès rouge" of Dr. Boué, and "the red sandstone formation" of Von Raumer, are but various modes of expressing the same complex idea. The one, rightly understood, is as significant as the other. But the subdivisions adopted by English geologists, when applicable, render the subject more distinct.

* I subjoin the following extracts from Dr. Boué's Essai Géologique sur l'Ecosse, in which his general view of the coal formation of Scotland is exhibited.

P. 168. "Les *assises inférieures* (du grès houiller) sont caractérisées par une quantité peu considérable de houille souvent sèche, par des amas variables d'anthracite, par des couches trappéennes et feldspathiques, par des calcaires compactes contenant des corps marins, et quelquefois par des grès rougeâtres."

"Dans les *assises supérieures*, les couches trappéennes semblent disparoître, et il n'y a plus *qu'une belle séric des grès houillers* associés avec *des calcaires* en partie compactes, en partie rendue sublamellaires par des débris d'êtres marins, et en partie marneux, empâtant des coquillages et des morceaux de végétaux."

"On observe cependant encore çà et là, des dépôts charbonneux où les calcaires paraissent manquer entièrement ou presqu' entièrement, où les impressions de fougères et de plantes marécageuses monocotylédones sont extrêmement abondantes, et où il y a des lits contenant des coquillages voisins de certaines bivalves fluviatiles; et l'on est amené à soupçonner d'après ces caractères, et d'après les analogies géognostiques, qu'il serait possible que ces dernières parties fussent les portions les *plus supérieures* de cette grande déposition houillère."

P. 198. "Les assises supérieures du depot charbonneux forment presque seules pour le mineur le véritable terrain houiller exploitable; néanmoins certaines parties, avons nous dit, méritent d'être distinguées à cause de leur manque de couches calcaires, leur abondance de houille et d'impressions végétales et leurs coquilles fossiles fluviatiles; ces dernières espèces de dépôts fort considérables en Angleterre sont rares en Ecosse, et je ne puis placer parmi eux, que certaines parties de Clackmannanshire et des environs de Falkirk et de St. Andrews, sans vouloir aucunement leur assigner une place exacte."

P. 352. "Dans la série houillère, nous avons surtout insisté sur la *quantité considérable de couches de calcaire à encrines* que contenaient la *plupart des houillères Ecossaises*, et sur le petit nombre de localités où les calcaires venaient à manquer presqu' entièrement, et où l'on apercevait quelques coquillages fluviatiles."

* See Notes to Cuvier's Essay on the Theory of the Earth, Third Edition, p. 287.

improbable that the old red sandstone itself should contain incidentally single beds of coal? Applying this observation, the single beds of coal adverted to by Freiesleben as lying in the rothliegende, in contradistinction to the continuous coal tract, will be found to imply nothing more than the distinction now taken.

It follows from all that has been advanced, that to lay down rigid rules with respect to the *details* of any particular series, forming part of the structure of the earth, so that they should be always applicable in the same manner in different countries, is to expect nature to appear in shackles, which she is not in the habit of wearing. The prevalence of a general order of succession is indisputable; but no less so is the variable state in which correlative members of the same series are associated together; being found in one country distinct from, and in another more or less frequently interstratified, with each other. Of this truth, the members of the carboniferous series afford many illustrative examples; while the limestone forms in general the great connecting link between the fundamental old red sandstone free from coal, on the one hand, and the coal measures free from limestone, on the other.

When on the eve of transmitting the preceding pages to the press, the *Annals of Philosophy* for March, 1823, arrived, containing the continuation of Mr. Conybeare's interesting memoir. I perceive no reason to alter any thing that I have written, professing, as I do, to have faithfully expounded the positions of Freiesleben; positions quite in accordance with analogous relations in Great Britain. It is for those geologists who advocate doctrines in opposition to demonstrate their fallacy. Here, however, I cannot avoid complaining that, while the authority of Freiesleben is repeatedly appealed to in the course of this controversy, his distinctions are not only frequently suffered to pass without due attention, but his statements are tried by a language in a great measure foreign to his own. The work of Freiesleben should be judged not partially, but as a consistent whole, taken all together.

With great respect for my adversary, as well as for Prof. Buckland, I cannot surrender my opinion of the accuracy of a writer (without ample proof to the contrary), who, during a residence of seven years in a country, made its geological relations an express object of his study; comparing them also with those of analogous tracts in other parts of Germany, both by his own researches, and those of other naturalists. The opinion attributed by my opponent to Von Humboldt (an illustrious name, and carrying weight with it on any subject), will not, I apprehend, on due examination, be found at all discordant with the

statements of Freiesleben.* That of Dr. Boué, expressing that what is *exclusively* called rothetodtliegende by Mr. Conybeare, is not the old red sandstone of *English* geologists, will be readily acceded to, since the former constitutes in fact (with the exception of the weissliegende) the upper part of the carboniferous series of Freiesleben; but, let it be remembered, this is only one part of the question, and not inconsistent with the general view of that author.† The account given by D'Aubuisson also, though insufficient in several respects, is not incompatible with this view, by whom indeed the rothetodtliegende is expressly referred to the *same formation* as the *terrain houiller*, composing the principal part of its mass.‡ The language of Beudant likewise is of a similar import, who also expressly ascribes the rothliegende in question to the same series as the carboniferous, designating the latter by the general term of the *red sandstone formation*, and comparing it with that of Scotland as described by Prof. Jameson, Dr. Mac Culloch, and Dr. Boué.§ On this subject, Mr. Conybeare observes, "whether it (namely, the rothetodtliegende *exclusively* so called by him) be more properly referable to the upper part of the carboniferous, or the lower part of the saliferous series, is a distinct question, on which much division of opinion exists, and which is after all not very material. I have endeavoured to compromise the matter by treating it as an intermediate link between them." I cannot subscribe to this doctrine. There can be no compromise upon a question of truth and error; nor can it surely be deemed immaterial to which series the rothliegende in dispute belongs, if we place a just value on a correct knowledge of the respective relations of the two series. My surprise is, that any division of

* A reference, however, to the Comparative View taken by that distinguished naturalist of the English and Continental floetz formations, will at once show that it is deficient in several important particulars.—(See D'Aubuisson, Traité de Géognosie, vol. ii. p. 255.)

† See Dr. Boué in vol. iv. of the Wernerian Memoirs.

‡ See Traité de Géognosie, vol. ii. p. 252. "Le *grès rouge*, que nous appelerons *grès houiller*, le terrain à houille en faisant partie, repose immediatement sur le terrain primitif ou intermediare." P. 263. "La grande formation de *grès houiller* se divise très convenablement en deux parties; l'une comprend le *terrain houiller* proprement dit; et l'autre le grès, appelé, dans la Thuringe, *grès rouge*, avec ses couches subordonnées: mais tout en distinguant ces deux parties, nous remarquerons qu'elles appartiennent à *la même formation*; et quoique le terrain houiller soit le plus souvent *au dessous*, il lui arrive quelquefois d'être *entremelé* et même d'être *superposé* au grès rouge." And p. 306. "Le grès, masse principale du terrain houiller, *prend souvent une grande extension, en abandonnant*, au moins en majeure partie, la houille avec l'argile shisteuse qui l'envelope, et il constitue des terrains d'une grande etendue. Il a été principalement observé en Thuringe, où il est connu sous le nom de *rothetodtliegende*. Werner le nomme *grès rouge*, par suite de sa couleur habituelle dans ce pays."

§ See e. g. the extract from that author's Travels in Hungary, inserted in the 14th number of the Edinburgh Philosophical Journal, in particular, p. 269, and 273; and more generally, p. 267—273, which convey a clear account of the geological relations of the Saxon pitchstone, as well as of that of Italy (at Grantola on the Lago Maggiore). In both cases, the pitchstone is associated with porphyry, red sandstone, and conglomerate, the whole of which are referred to the carboniferous series.

opinion should exist after the detailed exposition of Freiesleben, which tended to reconcile all differences; and that greater weight should not have been attached to the judgment and descriptions of that author, the correctness of which upon other subjects has not hastily been called in question. But be this as it may, I am not aware that any German writer ever included any portion of the rothetodtliegende formation in the gypseous and saliferous series; while many, on the contrary, did comprehend the weissliegende in the carboniferous series. The former position, therefore, assumed by my antagonist, is in opposition to all German authority.*

The propagation of error is sometimes as rapid as simple. A

* If there be any one series in geology more distinct than another, as constituting in itself a complete system, wholly independent of preceding and subsequent series, it is the carboniferous. It is true that in its lower line of boundary, where imposed upon transition tracts, we often hear graduations spoken of, as taking place from the one series into the other. These, however, can be so considered only in a *mineralogical* sense (particularly when the transition sandstone, one of the later members of that series, and the first floetz or old red sandstone come in contact): certainly not in a *geological* sense; for though, in the first place, the two series may in certain quarters be in a conformable position, yet if the line of apposition be examined throughout its extent, a general unconformability in the arrangement of their respective strata will be found to prevail, the carboniferous series being merely adapted to the *form of the surface* of the transition (or primary, as it may happen); and, in the second place, the transition series is commonly distinguished by a considerable variety of trilobites and other organic remains, while the first floetz or old red sandstone is free from such remains; and the only trilobite that I am acquainted with (beside the Oniscites Derbiensis of Martin) as occurring in the carboniferous limestone is a distinct species, and, I believe, also peculiar to that limestone.*

The upper confines of the carboniferous series are also equally well marked. In England, the calcareous or new conglomerate (the first member of the gypseous and saliferous series) is, I apprehend, invariably found in an unconformably overlying position; in some quarters partially overspreading the surface of the coal fields, and extending thence in like manner to the carboniferous limestone, and even to the old red sandstone. The weissliegende or new conglomerate in Germany also, with its companion the cupriferous marl shale, is represented by Freiesleben as partially overspreading the carboniferous series, conforming to the figure of its surface, following its sinuosities, and surrounding the detached portions of that series that appear in isolated hills; being also in certain quarters in contact with transition tracts. Hence arises a variableness in the range and dip of the weissliegende, which are sometimes conformable, sometimes unconformable to the disposition of the subjacent members of the carboniferous series. That the weissleigende or new conglomerate is wholly distinct from that series is also proved; 1. By its several affinities to the cupriferous marl shale; and 2. By its being affected in common with that shale, and with the lower alpine limestone in general, and the zechstein in particular, by various disturbances, which do not extend to the carboniferous series beneath.—(See e. g. Freiesleben, vol. iii. p. 51, et seq. and p. 239, et seq.; also vol. iv. p. 21—31.)

I may here remark, that in one respect there is a marked difference between the composition of the calcareous or new conglomerate of England, and that of the weissliegende of Germany. In the former, rounded and angular fragments of limestone are very common, and frequently predominant; while in the latter they are of rare occurrence. Both conglomerates thus bear a close relation to the carboniferous series on which they respectively repose, and from whose detritus they were principally derived; the limestone frequently prevailing in the British carboniferous series, and being, comparatively speaking, only incidental in the German.

* It is the tuberculated species depicted in pl. 4, fig. 12, of Brongniart's valuable Histoire Naturelle des Trilobites, derived from the Dublin limestone. I found four specimens of the same trilobite in the Mendip limestone. Mr. Miller has observed it likewise in the limestone of Cork and Bristol. It has been met with also incidentally in the carboniferous limestone of other parts of Great Britain.

judgment is pronounced by a name of celebrity; it is adopted and repeated by other names, perhaps of equal repute; and thus that which was originally a mistake, becomes a rule established by authority. But on recurring to first principles, the error is discovered, and truth at length prevails.

To conclude in the words of Lord Bacon, "the harmony of a science, supporting each part the other, is, and ought to be, the true and brief confutation and suppression of all the smaller sorts of objections."

Article II.

On the Crystalline Form of Ice. By James Smithson, Esq. FRS.

(To the Editor of the *Annals of Philosophy.*)

SIR, *March* 4, 1823.

I have just seen a memoir in the Annales de Chimie et de Physique for Oct. 1822, but published about a month ago, on the crystalline form of ice.

Mr. Hericart de Thury is said to have observed ice in hexagonal and triangular prisms; and Dr. Clarke, of Cambridge, in rhomboides of 120° and 60°.

M. Haüy supposed the form to be octahedral, and so did Romé de l'Isle; and, if I mistake not much, there is in an ancient volume of the Journal de Physique by Rozier, an account of ice in acute octahedrals.

Are these accounts and opinions accurate?

Hail is always crystals of ice more or less regular. When they are sufficiently so to allow their form to be ascertained, and which is generally the case, it is constantly, as far as I have observed, that of two hexagonal pyramids joined base to base, similar to that of the crystals of oxide of silicium or quartz, and of sulphate of potassium. *One of the pyramids is truncated,* which leads to the idea that ice becomes electrified on a variation of its temperature, like tourmaline, silicate of zinc, &c.

I do not think that I have measured the inclination of the faces more than once. The two pyramids appeared to form by their junction an angle of about 80 degrees.

Snow presents in fact the same form as hail, but imperfect. Its flakes are skeletons of the crystals, having the greatest analogy to certain crystals of alum, white sulphuret of iron, &c. whose faces are wanting, and which consist of edges only.

In spring and autumn; that is, between the season of snow and that of hail, the hail which falls partakes of the nature of both, is partly the one and the other; its crystals, though regular, are opaque, of little solidity, and consist, like snow, of an imperfect union of grains, or smaller crystals.

Article III.

Account of some Specimens of Rocks, &c. from Van Dieman's Land, and from New South Wales. By N. J. Winch, Esq. Hon. MGS.

(To the Editor of the *Annals of Philosophy.*)

Sir, *Newcastle-upon-Tyne, March 27, 1823.*

The Literary and Philosophical Society of this place has lately been presented with a considerable number of minerals by the Rev. T. H. Scott, of Whitfield, collected by himself in Van Dieman's Land and New South Wales, during his travels in those distant regions. And notwithstanding duplicate specimens, and probably many which were not duplicates, had been given to the Universities of Cambridge and Oxford, and the Geological Society of London, still we possess a sufficient number to throw considerable light on the structure of Australia. By many theorists it has been conjectured that these lands are of more recent formation than those of the other parts of the globe, but with how little justice such an opinion has been adopted, the following brief description of some of the best defined species of our collection will evince.

From Van Dieman's Land.

1. A hard slaty sandstone of a pale-brown colour with impressions of flustræ, resembling those of Humbledon Hill, near Sunderland. Pectenites, and some other species of bivalve shell, in size and shape like a hazel nut. From a hill near Hobart's Town, 800 feet above the level of the sea.

2. A very fine grained white sandstone. Near Hobart's Town. If in sufficient quantity, this must be a valuable material for the purposes of building.

3. Coal, of the same species as the Newcastle coal. From Adventure Bay, eight miles distant from Hobart's Town.

4. Black bituminous shale, with spangles of silvery mica, and slight impressions of the leaves of some phænogamous plant. Above and below the coal at Hobart's Town.

5. Limestone, of a brownish-grey colour, compact texture, and splintery fracture, with veins of white quartz. Eight miles north-west of Hobart's Town. Not unlike some of the beds in our encrinal limestone formation.

6. A bluish grey trap rock, resembling the blue millstone rock of Andernach on the Rhine. Its structure is cellular, the cells containing minute globules of black obsidian, occasionally coated by a thin pellicle of iron ochre, owing to decomposition. The rocky part is easily reduced to a black slag, by the action of the blowpipe, and with the addition of borax, melts into a pale green glass filled with air bubbles. The obsidian is reduced with difficulty into a brilliant black glass. Masses of this rock

are found on stony plains, and it is used as mill stones in the colony.

From New South Wales.

1. Coal, resembling that of the north of England.

2. Coal shale, of an ash-grey colour, with impressions of the leaves of some phænogamous plant, probably an eucalyptus. These leaves are lanceolate, from four to six inches in length, by one or one and a half inch in breadth, and have left black impressions on the stone.

3. Wood, mineralized by silex; the interior of a dark-brown colour, and compact texture, the exterior, formed on the sap wood, pale-brown, and containing longitudinal pores.

4. Old red sandstone, of a dark reddish-brown colour, and made up of small grains of sand, and silvery mica, and enveloping rounded pebbles of white quartz. Pitt's Amphitheatre.

5. Greywacke, consisting of greenish-grey clayslate, inclosing small fragments of chesnut-brown flinty slate, and specks of calcareous spar. From the hills beyond Bathurst.

6. Chlorite slate, of a greenish-grey colour and silky lustre. From the same hills.

7. Gneiss, composed of white felspar, black mica, and glassy quartz. From Cox's river.

8. Granite, consisting of fine grained white felspar, glassy quartz, and silvery mica. Near Cox's river.

9. Large grained granite, chiefly composed of flesh-red felspar, with glassy quartz and silvery mica. From Lawson's Peak, beyond the Blue Mountains.

10. Epidote, of a pale-green colour, and granular texture.

11. Felspar porphyry, of a yellowish and greenish-white, with crystals of the same colour, mixed with opalescent quartz. Fragment of a rounded mass.

12. Rock crystal, six-sided prismatic crystals, of a smoke-grey colour, terminated by six-sided pyramids.

13. Clay ironstone, of a reddish-brown colour, in nodules.

14. Bog iron ore, of the same colour.

15. Bole, of a bright-red colour.

16. Iron pyrites.

From the examination of these minerals (provided the series be complete), the conclusions to be drawn are, that, with the exception of the diluvium, no formation more recent than our magnesian limestone, has been found in Van Dieman's land, or our coal formation in New South Wales. That the mountain limestone, old red sandstone, greywacke, porphyry, clayslate, chlorite slate, gneiss, and granite, follow each other in the same order of succession, as is the case in other parts of the world; that no pumice or recent lava have been detected; and that the most remarkable phenomenon is the existence of impressions of leaves of phænogamous plants in the shales.

N. J. WINCH.

Article IV.

On Reaumur's Experiments on the Congelation of the Metals. By Mr. J. B. Longmire.

(To the Editor of the *Annals of Philosophy.*)

SIR, *April* 3, 1823.

The experiments of Reaumur on cast-iron, bismuth, and antimony, lead to the conclusions, that these metals expand during congealation, and are lighter when solid than when fluid. But as such conclusions are at variance with the general law, that heat expands all bodies whose natural state is solidity, it becomes important to show, that Reaumur's experiments do not militate against this law.

Reaumur found that the metals just mentioned, when fluid, supported bodies specifically heavier than themselves in the solid state; so that they should have contracted in melting, and would expand again in cooling.

A floating body is lighter than the fluid that supports it, *provided such fluid be quiescent.* None, however, of the melted metals, if exposed to the air, have the requisite degree of stillness, to form the fluid medium for obtaining accurate specific weights; but least of all, have cast-iron, bismuth, and antimony; metals that cool quickly, and that are in violent agitation, when passing down to the point of congealation. Fluid iron, for instance, has on its surface, bright glowing waves, rapidly repeated in variable situations; the hottest particles from below rise to the surface in these waves shed laterally to cool, and while they sink, others ascend, and give out part of their heat: this motion is repeated till the iron begins to consolidate. The other metals before-mentioned are nearly as much disturbed in cooling as fluid iron; hence in this state they are all too much agitated to determine with accuracy the difference of density between their solid and fluid states. So it follows that Reaumur's experiments depending on the aptitude of those melted metals for this purpose, are inconclusive, and cannot be considered as proving any thing against the general law, that all bodies, whose natural state is solidity, are heaviest in this state, and expand on receiving heat.

The force of the ascending particles in the melted metals before-mentioned, will account for the extra specific weight of the bodies that they support. But the amount of the ascentional force is not determinable; and whether these metals contract or expand in cooling is not yet shown by experiment. Such an experiment indeed is not easily performed; but to reconcile demonstratively the congealation of these metals with the law regulating that of all the others, is a desirable and important undertaking.

Article V.

Astronomical Observations, 1823.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

Mar. 30.	Emersion of π Scorpio from the moon.	12h	54′	16·4″	Mean Time at Bushey.
April 12.	Emersion of Jupiter's first satellite	8	53	55	Mean Time at Bushey.
		8	55	16	Mean Time at Greenwich.

Article VI.

On the Ultimate Analysis of Vegetable and Animal Substances.
By Andrew Ure, MD. FRS.*

The following is an account of Dr. Ure's process and apparatus for the ultimate analysis of vegetable and animal compounds, as described in this paper. The French chemists who have operated most with peroxide of copper in the analysis of organic substances, being aware of its quick absorption of humidity from the atmosphere, direct it to be used immediately after ignition, and to be triturated with the organic matter in a hot mortar of agate or of glass. "Yet this precaution," Dr. Ure observes, "will not entirely prevent the fallacy arising from the hygrometric action; for I find that peroxide thus treated does absorb, during the long trituration essential to the process, a certain quantity of moisture, which, if not taken into account, will produce serious errors in the analytical results. It is better, therefore, to leave the powdered peroxide intended for research, exposed for such time to the air, as to bring it to hygrometric repose, then to put it up in a phial, and by igniting 100 grains of it in a proper glass tube, sealed at one end, and loosely closed with a glass plug at the other, to determine the proportion of moisture which it contains. This, then, indicates the constant quantity to be deducted from the loss of weight which the peroxide suffers in the course of the experiment. The mortar should be perfectly dry, but not warm."

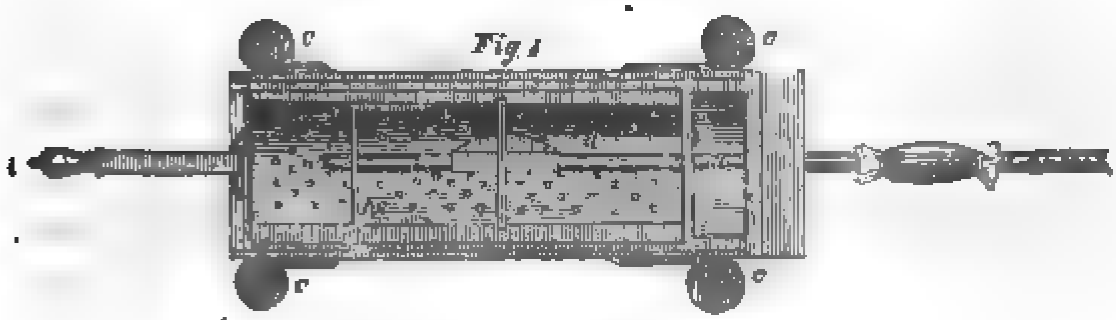
"Experimenters have been at great pains to bring the various organic objects of research to a state of thorough desiccation before mixing them with the peroxide of copper; but this prac-

* Abstracted from the Philosophical Transactions for 1822. Part II.

tice introduces a similar fallacy to that above described. ...... The plan which I adopt for the purpose of desiccation seems to answer very well. Having put the pulverulent animal or vegetable matter into short phials, furnished with ground glass stoppers, I place the open phials in a large quantity of sand heated to 212° F. in a porcelain capsule, and set this over a surface of sulphuric acid in an exhausted receiver. After an hour or more, the receiver is removed, and the phials instantly stopped. The loss of weight shows the total moisture which each of them has parted with; while the subsequent increase of their weight, after leaving them unstopped for some time in the open air, indicates the amount of the hygrometric absorption. This is consequently the quantity to be deducted in calculating experimental results."

"Many chemists, particularly in this country, have employed the heat of a spirit-lamp, instead of that produced by the combustion of charcoal, for igniting the tube in which the mixed materials are placed. I have compared very carefully both methods of heating, and find that for many bodies, such as coal, and resin, which abound in carbon, the flame of the lamp is insufficient; while its application being confined at once to a small portion of the tube, that uniform ignition of the whole, desirable towards the close of the experiment, cannot be obtained.* I was hence led to contrive a peculiar form of furnace, in which, with a handful of charcoal, reduced to bits about the size of small filberts, an experiment may be completed without anxiety or trouble, in the space of half an hour. Since I have operated with this instrument, the results on the same body have been much more consistent than those previously obtained with the lamp; and it is so convenient that I have sometimes finished eight experiments in a day."

Dr. Ure next gives a particular account of the whole apparatus he employs, illustrated with an engraving. "Fig. 1 is an

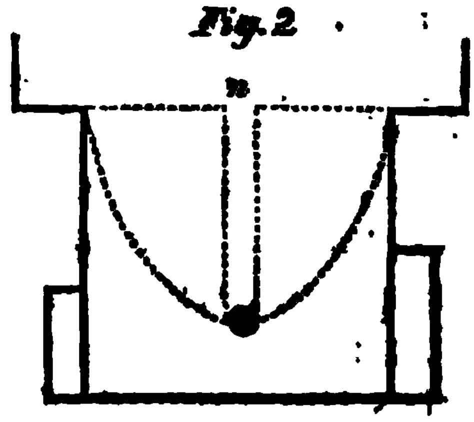


horizontal section of the furnace, in which we perceive a semi-cylinder of thin sheet iron, about eight inches long, and three

* Some remarks, by Dr. Prout, on the relative accuracy of analyses performed by means of the charcoal and of the lamp apparatus, will be found in the *Annals* for Dec. last, p. 425.—*Edit.*

and a half wide, perforated with holes, and resting on the edge of a hollow prism of tin-plate, represented more distinctly in fig. 2, where *n* shows a slit, through which the sealed end of the glass tube may be made to project, on occasion. Fig. 1, *i* is a handle attached to the semicylinder, by which it may be slid backwards or forwards, and removed at the end of the process. *d* is a sheath of platinum foil, which serves, by aid of a wire laid across, to support the middle of the tube, when it is softened by ignition. At *g* the plates which close the ends of the semi-cylinder and tin-plate prism, rise up a few inches to screen the pneumatic apparatus from the heat."

Fig. 2



A third occasional screen of tin-plate is hung on for the same purpose. "All these are furnished with slits for the passage of the glass tube. This is made of crown glass, and is generally about nine or ten inches long, and three-tenths of internal diameter. It is connected with the mercurial cistern by a narrow tube and caoutchouc collar. This tube has a syphon form, and rises about an inch within the graduated receiver. By this arrangement, should the collar be not absolutely air-tight, the pressure of the column of mercury causes the atmospheric air to enter at the crevice, and bubbles of it will be seen rising up without the application of heat. At the end of the operation, the point of the tube is always left above the surface of the mercury, the quantity of organic matter employed being such as to produce from six to seven cubic inches of gaseous product, the volume of the graduated receiver being seven cubic inches."

"As the tubes with which I operate have all the same capacity, viz. half a cubic inch; and as the bulk of materials is the same in all the experiments, one experiment on the analysis of sugar or resin, gives the volume of atmospheric air due to the apparatus, which volume is a constant quantity in the same circumstances of ignition. And since the whole apparatus is always allowed to cool to the atmospheric temperature, the volume of residual gas in the tubes comes to be exactly known, being equal, very nearly, to the primitive volume of atmospheric air left after the absorption of the carbonic acid in the sugar or resin experiment.* Thus this quantity, hitherto ill appreciated or neglected in many experiments, though it is of very great consequence, may be accurately found. At *k*, fig. 1, a little tin-plate screen is shown. It is perforated for the passage of the

* If *a* be the capacity of the graduated receiver, and *b* the spare capacity of the tubes, then the above volume is $b - \frac{b}{a+b}$.

tube, and may be slid along, and left at any part of the semi-cylindric cage, so as to preserve from the influence of the heat any requisite portion of the sealed end of the tube."

For the analysis of volatile liquids, Dr. Ure employs a little bulb, which, after it has been filled and exactly weighed, "is immediately slid down to the bottom of the tube, and covered with 150 or 200 grains of peroxide of copper. The bulb has a capacity equal to three grain measures of water, and its capillary point is sometimes closed with an inappreciably small quantity of bees' wax, to prevent the exhalation of the liquid, till the peroxide be ignited."

The furnace is provided with a cover, with an oblong orifice at its top, which serves for a chimney, "and may be applied or removed by means of its handle, according as we wish to increase or diminish the heat. *c c c c* are tin cases inclosing corks, through which the iron wires are passed, that support the whole furnace at any convenient height and angle of inclination."

"The tightness of the apparatus at the end of the process is proved by the rising of the mercury in the graduated receiver, by about one-tenth of an inch, as the tube becomes refrigerated."

"My mode of operating with the peroxide of copper," continues Dr. Ure, "is the following:

"I triturate very carefully in a dry glass mortar from one to two and a half grains of the matter to be analyzed, with from 100 to 140 grains of the oxide. I then transfer it by means of a platinum-foil tray and small glass funnel, into the glass tube, clearing out the mortar with a metallic brush. Over that mixture, I put 20 or 30 grains of the peroxide itself, and next, 50 or 60 grains of clean copper filings. The remaining part of the tube is loosely closed with 10 or 12 grains of amianthus, by whose capillary attraction the moisture evolved in the experiment is rapidly withdrawn from the hot part of the tube, and the risk of its fracture thus completely obviated. The amianthus serves moreover as a plug, to prevent the projection of any minute particles of filings, or of oxide, when the filings are not present. The tube is now weighed in a very delicate balance, and its weight is written down. A little cork, channelled at its side, is next put into the tube, to prevent the chance of mercury being forced backwards into it, by any accidental cooling or condensation. The collar of caoutchouc is finally tied on, and the tube is placed, as is shown in fig. 1, but without the plate *k*, which is employed merely in the case of analysing volatile liquids. A few fragments of ignited charcoal are now placed under the tube at the end of the furnace next to the cistern, and the remaining space in the semi-cylinder is filled up with bits of cold charcoal. The top may then be put in its place, when the operation will proceed spontaneously, the progressive advance

of the ignition from one end to the other being proportioned to the expansion of glass, so that the tube very seldom cracks in the process. Indeed I have often used the same tube for a dozen experiments, in the course of which it became converted into *vitrite*, or Reaumur's porcelain."

Since the evolved gas is saturated with moisture, Dr. Ure reduces it to the volume of dry gas, by help of a table, which he gives, computed by the well-known formula from his table of the elastic force of steam, published in the Phil. Trans. for 1818.

In certain cases, where the quantity of hydrogen is small, or where, as in the example of indigo, its presence has been denied, Dr. Ure employs pulverulent calomel instead of peroxide of copper. "The organic compound being intimately mixed with that powder, and gently heated, the muriatic acid gas obtained demonstrates the presence, though half of its volume will not give the total quantity of hydrogen; for a proportion of this elementary body continues associated with oxygen in the state of water."

Dr. Ure next gives, in detail, one example of the mode of computing the relation of the constituents from the experimental results, and then states the other analyses in a tabular form.

"1·4 grain of sulphuric ether, specific gravity 0·70, being slowly passed in vapour from the glass bulb through 200 grains of ignited peroxide of copper, yielded 6·8 cubic inches of carbonic acid gas at 66° Fahr. which are equivalent to 6·57128 of dry gas at 60°. This number being multiplied by 0·127 = the carbon in one cubic inch of the gas, the product 0·8345256, is the carbon in 1·4 grain of ether; and 0·8345256 × $\frac{8}{3}$ = 2·2254 = the oxygen equivalent to the carbonic acid. The tube was found to have lost 4·78 grains in weight, 0·1 of which was due to the hygrometric moisture in the oxide, and 1·4 to the ether. The remainder, 3·28, is the quantity of oxygen abstracted from the oxide by the combustible elements of the ether. But of these 3·28 grains, 2·2254 went to the formation of the carbonic acid, leaving 1·0546 of oxygen, equivalent to 0·1318 of hydrogen. Hence, 1·4 ether, by this experiment, which is taken as the most satisfactory of a great number, seem to consist of

Carbon	0·8345
Hydrogen	0·1318
Water	0·4337
	1·4000

And in 1 grain we shall have

Carbon	0·5960	3 atoms	2·25	60·00
Hydrogen	0·1330	4 atoms	0·50	13·33
Oxygen	0·2710	1 atom	1·00	26·66
	1·0000		3·75	100·00

Or, 3 volumes olefiant gas = 3 × 0·9722 = 2·9166
2 volumes of water. .... 2 × 0·625 = 1·25

$$\overline{4{\cdot}1666}$$

which suffering a condensation equal to the whole vapour of water, will give an ethereous vapour, whose specific gravity is 2·5.

"The proportion of the constituents of sulphuric ether, deduced by M. Gay Lussac from the experiments of M. Th. de Saussure, are 2 volumes olefiant gas + 1 volume vapour of water, which 3 volumes are condensed into 1 of vapour of ether, having a specific gravity = 2·58. The ether which I used had been first distilled off dry carbonate of potash, and then digested on dry muriate of lime, from which it was simply decanted, according to the injunction of M. de Saussure. Whether my ether contained more aqueous matter than that employed by the Genevese philosopher, or whether the difference of result is to be ascribed to the difference in the mode of analysis, must be decided by future researches."

"By analogous modes of reduction, the following results were deduced from my experiments. I ought here to state, that in many cases the materials, after being ignited in the tube, and then cooled, were again triturated in the mortar, and subjected to a second ignition. Thus, none of the carbon could escape conversion into carbonic acid. I was seldom content with one experiment on a body; frequently six or eight were made."

TABLE OF ORGANIC ANALYSES.

	Substance.	Carbon.	Hydrogen.	Oxygen.	Azote.	Water.	Excess.
1	Sugar	43·38	6·29	50·33		56·62	
							Oxygen
2	Sugar of diabetes	39·52	5·57	54·91		51·13	10·35
3	Starch..................	38·55	6·13	55·32		55·16	6·03
4	Gum arabic	35·13	6·08	55·79	·3 ?	54·72	7·15
							Hydrogen
5	Resin	73·60	12·90	13·50		15·20	11·20
6	Copal	79·87	9·00	11·10		12·05	7·06
7	Shell lac................	64·67	8·22	27·11		30·51	4·82
8	Resin of guaiac............	67·88	7·05	25·07		28·00	3·93
9	Amber..................	70·68	11·62	17·77		20·00	9·40
10	Yellow wax..............	80·69	11·37	7·94		8·93	10·39
11	Caoutchouc	90·00	9·11	0·88		0·99	9·00
12	Splent coal..............	70·90	4·30	24·80		27·90	1·20
13	Cannel coal	72·22	3·93	21·05	2·08	23·68	1·80
14	Indigo..................	71·37	4·38	14·25	10·00	16·00	2·52
15	Camphor	77·38	11·14	11·48		12·91	9·71
16	Naphthaline..............	91·06	7·07	0·70?		0·79?	
17	Spermaceti oil	78·91	10·97	10·12		11·34	9·71
18	Common oil of turpentine.	82·51	9·62	7·87		8·85	8·64
19	Purified oil of turpentine. .	84·09	11·05	3·06		4·00	11·01
20	Naphtha................	83·04	12·31	4·65		5·23	11·73
21	Asiatic castor oil	74·00	10·29	15·71		17·67	8·33
22	Alcohol, spec. grav. 0·812.	47·85	12·24	39·91		44·09	7·25
23	Ether, spec. grav. 0·70...	59·60	13·03	27·01		30·05	9·99

TABLE OF ORGANIC ANALYSES.

	Substance.	Carbon.	Hydrogen.	Oxygen.	Azote.	Water.	Excess.
							Oxygen
24	Bleached silk	50·69	3·94	34·04	11·33	35·43	2·55
25	Cotton...................	42·11	5·06	52·83		45·56	12·33
26	Flax, by Lee's process....	42·81	5·05	51·07		49·05	7·07
27	Common flax............	40·74	5·57	52·79	0·09	50·16	8·02
28	Wool....................	53·07	2·80	31·02	12·03	25·07	8·03
							Hydrogen
29	Cochineal...............	50·75	5·81	36·53	6·91	39·06	14·01
30	Cantharides.............	48·64	5·99	36·29	9·08	40·83	14·53
31	Urea....................	18·57	5·93	43·68	31·82	49·14	0·47
32	Benzoic acid............	66·74	4·94	28·32		31·86	1·04
							Oxygen
33	Citric acid	33·00	4·63	62·37		41·67	25·33
34	Tartaric acid	31·42	2·76	65·82		24·84	43.74
35	Oxalic acid..............	19·13	4·76	76·20		42·87	38·09
36	Ferroprussic acid.........	36·82	27·89 of	iron.	35·29		

"*Remarks on the preceding Analyses.*"

"The sugar which I employed," says Dr. Ure, "had been purified by Mr. Howard's steam process, and was so well stove-dried, that it lost no appreciable portion of its weight, when enclosed along with sulphuric acid in *vacuo*. The diabetic sugar has a manifest excess of oxygen, which, I believe, to be the case with all weak sugars, as they are called by the sugar refiners. I consider this excess of oxygen as the chief cause which counteracts crystallization, and, therefore, the great obstacle to the manufacturer. The smallest proportion of carbon, which I have ever found in any cane sugar, was upwards of 41 per cent. The experiments on starch and gum were among the earliest which I made, and the results differ so much from those given by other experimenters, that I shall repeat the analyses at the earliest opportunity. The constituents of the above three bodies, referred to the prime equivalent scale, will be approximately as follows: *

	Sugar.	Starch.	Gum.
Carbon......	5 atoms	.... 5 atoms	.... 4 atoms
Oxygen.....	4	 5	 5
Hydrogen...	4	 4	 4

"Starch is liable to a similar deterioration with sugar; that is, some species of it make a much firmer coagulum with hot water than others; a difference probably due to the proportion of oxygen. The starch here employed was that of commerce, and was not chemically desiccated: hence, the redundancy of water beyond the equivalent proportion. A little hygrometric moisture was present also in the gum, as it was not artificially

* The following are the equivalent numbers employed by Dr. Ure in this paper:— Oxygen, 1·0; hydrogen, 0·125; carbon, 0·75; azote, 1·75.

dried. A note of interrogation is placed after azote. That doubt will I trust be solved, when I complete my analyses of grains, roots, and leaves, with the view of tracing the origin of azote in the bodies of graminivorous animals...... With regard to resin, I believe the quantity of its carbon to be somewhat underrated in the table. Though three experiments were made on it, I now perceive that I had omitted to retriturate and reignite; and the carbon of resin is very difficult of oxygenation. Its true composition is probably, carbon, 8 atoms; hydrogen, 8; oxygen, 1. A still more symmetric arrangement would be derived from carbon, 8 atoms; hydrogen, 9; oxygen, 1. This proportion corresponds to 8 atoms of olefiant gas and 1 atom of water; and I think it is very possibly the true constitution of resin. Had the loss of weight suffered by the contents of the tube, during their ignition, been a few hundredth parts of a grain more, the experimental result would have coincided with this theoretical view. Copal approaches to carbon, 10 atoms; hydrogen, 7; oxygen, 1. Lac may be nearly represented by carbon, 6 atoms; hydrogen, 4; oxygen, 2; or 2 atoms of olefiant gas + 1 atom carbonic oxide...... Resin of guaiac gives carbon, 7 atoms; hydrogen, 4; oxygen, 2."

"Although the experiments on amber were conducted carefully with retrituration and reignition, no good atomic configuration of it has occurred to me. It approaches to 10 carbon + 10 hydrogen + 2 oxygen."

"Wax is apparently composed of carbon, 13 atoms; hydrogen, 11; oxygen, 1; or, in other words, of 11 atoms olefiant gas + 1 atom carbonic oxide + 1 atom carbon. Had the experiment given a very little more hydrogen, we should have had wax as consisting of 12 atoms olefiant gas + 1 atom carbonic oxide. This is possibly the true constitution."

"Caoutchouc seems to consist of carbon, 3 atoms; hydrogen, 2; or it is a sesqui-carburetted hydrogen. The oxygen deduced from experiment is in such small quantity, as to leave a doubt whether it be essential to this body, or imbibed in minute quantity from the air during its consolidation."

"Splent or slate coal, specific gravity 1·266, abstracting its incombustible ashes, approaches in constitution, to carbon, 7 atoms; hydrogen, 3; oxygen, 2. Cannel coal from Woodhall, near Glasgow, specific gravity 1·228, resembles a compound of carbon, 9 atoms; hydrogen, 3; oxygen, 2. In both of these bodies, there is an excess of carbon beyond the 3 atoms of olefiant gas and 2 of carbonic oxide. The former coal has 2 extra atoms of carbon, and the latter, 4 atoms. Hence this coal is found at the Glasgow gas works to yield a very rich burning gas."

"The elements of indigo may be grouped as follows: carbon, 16 atoms; hydrogen, 6; oxygen, 2; azote, 1; or, in other

terms, we shall have 1 atom cyanogen, 6 atoms olefiant gas, 2 atoms carbonic oxide, and 6 atoms of carbon in excess."

"I had intended to pursue, at considerable detail, my researches on this curious azotized product of vegetation, but the subject having been lately taken up, and ingeniously prosecuted by my pupil and friend, Mr. Walter Crum, I was induced to leave it in his hands. He announced to me the presence of hydrogen in indigo, before I had analyzed this substance myself; and drew my attention particularly to the fallacy occasioned by the hygrometric water of the peroxide of copper. It is likely that some slight modification may require to be made in my tabular proportion of the constituents, for I did not resume the subject of indigo, after I had become most familiar with the manipulations."

"Camphor is very nearly represented by carbon, 10 atoms; hydrogen, 9; oxygen, 1; or 9 atoms olefiant gas + 1 atom carbonic oxide. Napthaline is, in my opinion, a solid bicarburet of hydrogen, consisting of carbon, 2 atoms; hydrogen, 1."

"It is very difficult, even by the best regulated ignition, to resolve the whole carbon of this very volatile body into carbonic acid; hence, the carbon may come to be underrated in the result." Naphthaline is obtained during the rectification of the petroleum of the coal gas works. It is found encrusting the pipes in the form of a greyish crystalline mass; and when purified by a second sublimation at the temperature of about 220°, it forms beautiful thin plates, white and glistening. It has a powerful petroleum odour. With brine of the specific gravity 1·048, these plates, when once thoroughly wetted (which is difficult to effect), remain in equilibrium; that is, float in any part of the liquid. That number, therefore, represents the specific gravity of naphthaline. It is insoluble in water, but very soluble in ether, and moderately so in alcohol. With iodine, it fuses at a gentle heat into a brown liquid, forming as it cools a solid resembling plumbago, which dissolves readily in alcohol, and is thrown down by water. Naphthaline is soluble in oils. In water heated to 168° Fahr. it fuses, and remains like oil at the bottom of the liquid; bat when stirred, it rises, and spreads on the top in little oily patches. At 180° it rises spontaneously from the bottom in oily globules, which, as the temperature is raised, dissipate in the air, undergoing motions similar to those of camphor floating on water.

"Spermaceti oil is constituted apparently of carbon, 10 atoms; hydrogen, 9; oxygen, 1; or, in other words, of 9 atoms olefiant gas + 1 atom carbonic oxide. The experimental proportion is, however, more nearly carbon, 10 atoms; hydrogen, 8; oxygen, 1. There is here an atom of carbon in excess."*

* "This is probably the truer view. The former would make it coincide with camphor."

"Common oil of turpentine, specific gravity 0·888, comes very closely to the following arrangement: carbon, 14 atoms; hydrogen, 10; oxygen, 1. Oil of turpentine, purified with alcohol by Dr. Nimmo's method, seems to approach to the constitution of naphtha, or of a mere carburet of hydrogen. Its specific gravity is 0·878. But as from the mode of preparing it, a minute portion of alcohol may remain in it, I do not think it necessary to investigate its atomical structure."

"Naphtha, specific gravity 0·857, obtained by distillation from petroleum, is very nearly represented by carbon, 22 atoms; hydrogen, 20; oxygen, 1. It, therefore, consists of 20 atoms olefiant gas, 1 atom carbonic oxide, and 1 atom of carbon held in solution."

"Castor oil is an interesting unctuous body, from its great solubility in alcohol. It consists nearly of carbon, 7 atoms; hydrogen, 6; oxygen, 1. It is composed, therefore, of 6 atoms olefiant gas + 1 atom carbonic oxide."

"Alcohol, specific gravity 0·812, is composed very nearly of carbon, 3 atoms; hydrogen, 5; oxygen, 2; or, of 3 atoms olefiant gas = 2·625, 2 water = 2·25. And in volumes, 3 olefiant gas = ·9722 × 3 = 2·9166; 4 aqueous vapour = ·625 × 4 = 2·500.

"Thus alcohol of 0·812, by the above analysis, which I believe merits confidence, from the care and consistency of the experiments, differs from M. Gay-Lussac's view of absolute alcohol, deduced from M. Th. de Saussure's experiments, in containing an additional volume of aqueous vapour. At the specific gravity ·814, alcohol would have exactly this atomic constitution. If the condensation be equal to the whole 3 volumes of olefiant gas; that is, if the 7 volumes of constituent gases become 4 of alcohol vapour, we shall have its specific gravity at this strength = 1·3722; the additional volume of aqueous vapour producing necessarily this abatement in the density."

"Fibres of the bleached threads of the silk-worm were subjected to analysis. Their composition is apparently, carbon, 10 atoms; hydrogen, 4; oxygen, 5; azote, 1; or, 4 of olefiant gas, 5 of carbonic oxide, and 1 of nitrous oxide; or of 1 atom prussic acid, 3 atoms olefiant gas, and 5 atoms carbonic oxide."

"Cotton fibres, unbleached, seem to consist of carbon, 11 atoms; hydrogen, 8; oxygen, 10. Flax, by Lee's patent process, consists of carbon, 7 atoms; hydrogen, 5; oxygen, 6. It contains more carbon, and is therefore probably stronger than common flax, prepared by a putrefactive maceration. This seems composed of carbon, 1 atom; hydrogen, 1; oxygen, 1. But this is the theoretical representation of sugar by M. Gay-Lussac and Dr. Prout; and hence, these chemists would readily explain, how linen rags may pass into the form of sugar by the action of sulphuric acid. Wool approximates to carbon, 10 atoms; hydrogen, 3; oxygen, 4; azote, 1."

"Cochineal seems to be made up of carbon, 15 atoms; hydrogen, 11; oxygen, 8; azote, 1. Cantharides approximate to carbon, 11 atoms; hydrogen, 10; oxygen, 7; azote, 1."

"My result with urea differs so considerably in the proportion of azote from that of Dr. Prout and M. Berard, that I am disposed to doubt of the accuracy of my experiments, though they were made with the utmost care, and were most consistent in the repetition. I could perceive no smell whatever of nitrous gas in the gaseous products, which were made to traverse a column of copper filings three inches long, in a state of ignition. I shall renew the inquiry on urea, and employ the lowest temperature compatible with the formation of carbonic acid."

"The prime equivalent of benzoic acid crystals, I find by saturation with water of ammonia, to be 14·5; and it consists apparently of carbon, 13 atoms; hydrogen, 6; oxygen, 4. Of crystalline citric acid, the prime equivalent is 8·375 by my experiments; and it consists probably of carbon, 4 atoms; hydrogen, 3; oxygen, 5; or, of 4 atoms carbon, 3 water, and 2 oxygen. Two of these atoms of water are separated, when citric acid is combined with oxide of lead in what is called the dry citrate. Hence, the acid atom is in this case 6·125. The prime equivalent of crystalline tartaric acid is 9·25 by my results; and it seems made up of carbon, 4 atoms; hydrogen, 2; oxygen, 6; or of carbon, 4 atoms; oxygen, 4; water, 2. From my experiments I have been led to conclude, that into dry tartrate of lead these two atoms of water *do* enter as a constituent; and hence, that the crystals of tartaric acid are as dry as is compatible with its constitution. Oxalic acid crystals have 7·875 for their prime equivalent, and are composed of carbon, 2 atoms; hydrogen, 3; oxygen, 6; or of 2 atoms carbon, 3 oxygen, 3 water. Into the dry oxalate of lead, these 3 atoms of water do *not* enter. Hence I find the dry acid to be composed of carbon, 2 atoms; oxygen, 3; or, of 1 atom carbonic acid + 1 atom carbonic oxide, as was first suggested, I believe, by Dobereiner. Crystallized oxalate of ammonia consists of 1 atom acid, 1 atom ammonia, and 2 atoms water, = 8·875. By a gentle heat, 1 atom of water may be separated; and an oxalate of ammonia, as dry as is compatible with its neutrality, remains."

"I have analyzed, by the peroxide of copper, the citrate, tartrate, and oxalate of lead; and on comparing the results thus obtained, with those derived from the analysis of the crystalline acids, I have come to the above determinations.

"Ferroprussic acid, the ferrocyanic acid of the French chemists, has proved hitherto a stumbling block to me, in reducing the results of my experiments to the atomic theory. I have subjected it to very numerous trials in many states of combination, and have sought, with great pains, to accommodate the results to the doctrine of prime equivalents; but hitherto without success. The following facts, however, may perhaps be deemed of some consequence.

"In the first place, the prime equivalent of the crystallized ferroprussiate of potash is 13·125, compared to oxide of lead 14, and to nitrate of the same metal 20·75; that is, 13·125 of the former salt neutralize 20·75 of the latter. In the second place, 14 parts of oxide of lead yield 21 parts of dry ferroprussiate of lead; or the atomic weight of dry ferroprussic acid is 7.

"The mean of my analyses of ferroprussiate of lead gives the relation of the constituents of the acid, as marked in the table. These proportions, reduced to the atomic weight 7, afford

Carbon	2·5774
Azote	2·4703
Ferreous matter	1·9523
	7·0000

"Were we to suppose the prime equivalent of the ferroprussic acid 7·5 instead of 7; and were we further to suppose that the carbon in the above result should be 2·25 = 3 atoms, and the azote = 3·5, or 2 atoms, then we might conceive an atom of dry ferroprussic acid to be made up of

Carbon	3 atoms	2·25
Azote	2	3·50
Iron	1	1·75
		7·50

"But experiment does not permit me to adopt this theoretical representation.

"The best mode that has occurred to me for analyzing ferroprussiate of potash, is to convert it, by the equivalent quantity of nitrate of lead, into the ferroprussiate of this metal; then to separate the nitrate of potash by filtration; and, after evaporation, to determine its weight. In this way, 13·125 grains of crystallized ferroprussiate of potash afford 12·33 grains of nitre, which contain 5·8 of potash.* By heating nitric acid in excess on 21 grains of ferroprussiate of lead, I obtained 2·625 grains of peroxide of iron, equivalent to 1·8375 of the metal. Hence I infer, that the iron in the ferroprussiate of lead is in the metallic state; for the joint weights of the carbon and azote contained in 7 grains of the dry acid is 5·0477; and the difference, 1·9523, approaches too closely to the above quantity, 1·8375, for us to suppose the metal to be in the state of protoxide. In fact, 2·625 parts of peroxide × 0·9 = 2·3625 of protoxide, is a quantity much beyond what experiment shows to be present."

* "By careful desiccation, 1·69 grain of water may be separated from 13·125 grains of the salt."

Article VII.

Memoir illustrative of a general Geological Map of the principal Mountain Chains of Europe. By the Rev. W. D. Conybeare, FRS. &c.

(*Continued from* p. 289.)

Sands immediately inferior to the Chalk (Green and Iron Sand). Craie Chloritee; in some Instances, Quadersandstein?

This formation, where most extensively displayed in England (the only country where it has yet received full attention), consists of the following deposits, each of considerable thickness.

1, and lowest. Beds of sand highly charged by brown oxide of iron containing lignites, associated occasionally with coarse limestone containing remains of turtles, crocodiles, and marine shells.

2. Blue marl.

3. Beds of sand usually coloured by green oxide of iron, but occasionally passing into the brown oxide, containing alcyonia and sponges, and abundant shells often chalcedonized.

4. Marl containing several peculiar multilocular shells (hamites turrilites, &c.), and bones of Saurian animals, passing by its lowest beds into No. 3, on which it rests, and by its upper beds into the inferior members of the chalk formation which cover it.

All these varieties, however, are by no means universally found even in England, and nothing beyond a general conformity to the type of the series taken collectively can be reasonably expected in distant countries.

Localities.—(A.) *England.*

In England, this series is very imperfectly exhibited in the northern counties, where traces only of it are to be seen under the chalk wolds of York and Lincolnshire, and crossing the æstuary of the Wash at Hunstanton cliff in Norfolk. In Cambridge, Bedford, and Buckinghamshire, the iron sand, No. 1, is well exhibited; but the upper members are more confused. It does not indeed appear that the green sand exists as a distinct deposit, but is rather blended with the marl, No. 4 (there called galt). In Oxfordshire and Berkshire the tract which lies along the course of these formations is low, and much concealed by diluvial debris; but insulated portions of the lowest deposit (the iron sand) sometimes form summits on the ranges of the oolitic hills. In Wiltshire, the green sand, No. 3, is shown in great force, as also on the confines of Dorset and Devon, where it forms the summit of the elevated platform of Blackdown Hills. Insulated ridges of similar character extend on the west of Exeter as at Haldon Hill, almost close to the transition district;

but the best opportunities of studying the whole formation are afforded by the eastern coast of Dorsetshire (the Isle of Purbeck), by the Isle of Wight, and more especially by the great denudation of the beds beneath the chalk in the south-eastern counties, including the Weald of Kent, Surrey, and Sussex, where all the beds above enumerated are displayed on the fullest scale. In the other British Islands, this formation only occurs in the north-east of Ireland, where it may be seen near Belfast supporting the chalk which underlies the great basaltic area of that district.

(B.) *France.*

In France these formations have been observed among those which circle round both the northern basin of the Seine and the south-western basin of the Garonne.

1. They range beneath the escarpment of the chalk hills surrounding the denudation of Boulogne, a continuation of that just mentioned as occupying the south-eastern counties of England.

2. They skirt round the exterior of the chalky zone bounding the basin of Paris, forming a broad sandy tract. Mr. de la Beche has distinctly described the commencement of these chains from the channel near the mouth of the Seine, and illustrated it in his excellent sections published in the Geological Transactions for 1822.

M. Omalius d'Halloy has described the series under the title of the lower chalk, which seems very unfortunately chosen, since it is only mineralogically applicable to a very small part of it (that corresponding to our chalk marl), and has led to much confusion both as to the description of the chalk formation itself, and its constituent fossils. This author notices the following subdivisions: 1. Chalk; sometimes of a coarser texture, occasionally mixed with clay, sand, and chlorite, containing pale flints abundantly. 2. Tuffeau; coarse sandy chalk mixed with chlorite. 3. Sands and sandstones; often mixed with calcareous matter. 4. Greyish clay; commonly of a marly character, sometimes mixed with chlorite: the passages of these modifications into one another, and their alternations prevent the decided determination of their order of superposition, further than the assigning the highest position in the series to No. 1.

The green sand occurs beneath the chalk at Valenciennes; it is there called Turtia.

3. In the basin of the Garonne this formation has been particularly observed by M. Bouè along its northern border, stretching from the Island of Aix near la Rochelle, to Perigord.

Humboldt has extracted from an unedited memoir of M. Fleuriau de Bellevue, some very interesting particulars concerning a large deposit of lignites connected with this formation in the vicinity of the Isle of Aix. They consist of dicotyledonous plants, partly petrified, partly bituminized, and sometimes in the state of jet: they are generally compressed, and lie sometimes

in regular horizontal beds, sometimes confusedly heaped together. They form a kind of submarine forest, extending in a band a league and a half in breadth from the north-west of the Isle of Oleron, 14 leagues to the interior of the mainland along the right bank of the Charente, about a metre below the level of the high tides. They are associated with a coarse grit containing bones of large marine animals. The geological constitution of the neighbourhood is said to be following an ascending order: 1. Compact lithographic limestone of an even fracture (La Rochelle St. Jean d'Angely), beds of oolite (point of Chatelaillon and Matha). 3. Lumachelle and beds of polypiers, with impressions of gryphœa angustata. (These three deposits are considered as representing the Jura limestones, and the latter as identical with the coral rag of England). 4. Great bed of lignite with marine peat, succin asphalte, and plastic clay. 5. Ferruginous and chloritose sand, slate clay, and argillaceous and calcareous beds with trigoniæ and cerithia, and fragments of lignite. On the south-west of the Charente, No. 4 and 5 are wanting, and a very white limestone said to be the lowest chalk rests immediately on the oolites. M. Boué has traced the prolongation of these lignites from Rochefort by Perigueux to Saltat in the Perigord.

Similar instances of the occurrence of lignite in this formation have been observed in England in the Isle of Purbeck, the Isle of Wight, and in the Weald of Sussex. Mr. Mantell has described the vegetable remains of the last-mentioned deposits in the forty-second page of his work on the geology of that district.

The iron ores of Perigord occur in this formation. M. Boué has also observed iron sand, green sand (with crabs and echinites), and chalk marle, on the SW. of the basin of the Garonne between Bayonne, St. Severs, and Dax. These deposits repose on the Jura limestone, which forms a band at the foot of the Pyrenees. Quadersandstein with lignites succeeds—then a few beds of Muschelkalk covering the great saliferous sandstone.

(C.) *Alps.*

On the northern borders of the Alps, the highest beds of the exterior calcareous chains consist of a dark-coloured limestone often mixed with sand and green particles, and agreeing in its fossils with this part of the English series, with the addition of nummulites, which are rare (although they do occasionally occur) in these beds in England. Similar beds are mentioned, and in a similar position, on the skirts of the Maritime Alps, near Nice, in Mr. Allan's account of that neighbourhood. (Ed. Phil. Trans.) They form the second limestone of the memoir referred to.

In Cuvier and Brogniart's Description Geologique des Environs de Paris, will be found an account of a formation of the same epoch with the craie chloritee, (the English green sand, and chalk marl,) in the chain of Buet, with a particular enumeration

of its fossils; and a description of a similar formation overlying the beds of Jura limestone at the loss of the Rhine, near Bellegarde.

(D.) *Germany.*

The prolongation of the Jura chain through Franconia is covered from near Ratisbon with formations, probably coeval with those now described.

I have already hinted my suspicions that more than one formation are confounded under the name of quadersandstein: that rock so called, which is obviously interposed between the Muschelkalk and Jura limestone, is probably the sand and sandstone of our inferior oolite; I still however conceive that much of the quadersandstein in the north of Germany will not be found placed in that relation, but rather corresponds with our green and iron sands; yet it is highly difficult to pronounce concerning a rock which is so seldom seen covered by any thing but diluvial detritus, and whose true place in the series must, therefore, rather be inferred from theory than ascertained by observation.

(E.) *Poland.*

Mr. Buckland considers the sand containing lignite which overlies the saliferous sandstones of the Wielickza mines, which M. Beudant hesitatingly refers to the tertiary molasse as belonging in truth to the green sand. Mr. Beudant's inference rests only on the occurrence of lignite, which he erroneously considered as peculiar to the tertiary sands, but which, as we have seen, is equally common in this formation. Mr. Buckland's opinion is rendered greatly more probable by the general structure of the country.

(*To be continued.*)

Article VIII.

A Means of Discrimination between the Sulphates of Barium and Strontium. By James Smithson, Esq. FRS.

(To the Editor of the *Annals of Philosophy*.)

SIR, *April 2, 1823.*

To distinguish barytes and strontian from one another, it is directed in No. 19 of the Journal of the Royal Institution to dissolve in an acid which forms a soluble salt with them, to decompose by sulphate of soda, and to add subcarbonate of potash to the filtered liquor. If the earth tried is strontian, a precipitate falls; if barytes, not.

When these matters are in a state to be soluble in an acid, a more certain, I apprehend, and undoubtedly a much easier pro-

ceeding, is to put a particle into a drop of marine acid on a plate of glass, and to let this solution crystallize spontaneously. The crystals of chloride of barium in rectangular eight-sided plates are immediately distinguishable from the fibrous crystals of chloride of strontium.

I have not repeated the process above quoted; but if sulphate of strontium did possess the solubility in water there implied, this quality presented a ready method by which mineralogists would be enabled to distinguish it from sulphate of barium. On trial I did not find water, or solution of sulphate of soda, in which sulphate of strontian had long lain, produce the least cloud on the addition of what is called subcarbonate of soda.

The means I have long employed to distinguish the two sulphates apart was to fuse with carbonate of soda, wash, dissolve in marine acid, &c.; but this process requires more time and trouble than is always willingly bestowed, and may even present difficulties to a person not familiarized with manipulations on very small quantities.

A few months ago a method occurred to me divested of these objections. The mineral in fine powder is blended with chloride of barium, and the mixture fused. The mass is put into spirit of wine, whose flame is coloured red if the mineral was sulphate of strontium. The red colour of the flame is more apparent when the spirit is made to boil while burning, by holding the platina spoon containing it over the lamp.

Article IX.

Observations on the Temperature, and general State of the Weather, on the Coast of Africa from the River Sierra Leone (8° 30′ N) *to the Equator, but principally in the Gulph of Guinea from Lat.* 5° N. *to the latter.* By Capt. B. Marwood Kelly, Royal Navy, late of his Majesty's Ship Pheasant.

(To the Editor of the *Annals of Philosophy*.)

Sir, *April* 4, 1823.

From local peculiarities in the state of the weather on these parts of the coast, it is usual to divide the year into seasons of a denomination different from other parts of the globe; in place of spring, summer, autumn, and winter, they are here called the tornado,* rainy, foggy, second or after rains, and fine seasons.

* These violent convulsions in the atmosphere so terrific to sailors, and which would be no less so to landsmen, if the state of cultivation was so far advanced, as to expose the husbandman's labour to the ravages of these dreadful tempests, first shows itself on the eastern quarter of the horizon by a deep black cloud heavily charged with electric fluid. This cloud continues increasing in size, sometimes for an hour or two before it is put in motion, and constantly emitting vivid flashes of lightning, accompanied by heavy and

From Sierra Leone and the rivers in its immediate vicinity, as far as Cape Appollonia, the tornado season sets in about the middle of April, and continues to the middle of June, when it is succeeded by the rains; at this time these violent convulsions in the atmosphere are frequent; rarely two days pass without one being experienced; and even in the early parts of the month of April, they are sometimes felt. The load of vapour from which the atmosphere is unburdened by them, renders the air pure and wholesome, and the rain which falls in torrents for the space of an hour dries up so immediately that they may be deemed as contributing much to the salubrity of the climate; even to shipping, except at anchor in the rivers, if due precautions are taken, they are attended with no danger, as the gust of wind always comes from the land, north of Cape Palmas, and in a parallel with it, east of that Cape, and with quite sufficient warning even for a merchant ship, with but few men, to make the necessary preparations.

About the middle of June, the rainy season commences, and continues to the beginning, and sometimes even to the latter end of November: from the little cessation of rain which takes place during this period, the ground soon becomes drenched, and from it a miasma arises which engenders those pestilential remittent fevers so destructive of human life in this part of the world.

As the rains begin to subside, they are succeeded by thick hazy weather, arising from a rapid evaporation of the moisture still remaining in the ground.

About the latter end of December, and during the whole of January, a wind occasionally blows, possessing properties, and attended by circumstances, peculiar to itself; it is known by the name of the Harmatan, and blows from the eastward with considerable strength. It is always attended by thick hazy weather, notwithstanding which it is so dry and parching, that all wood-work warps and shrinks, and, if united by glue, becomes detached. Paper and books appear as if they had been placed close by a fire. On the human frame its effects are considerably felt; the lips and nostrils become sore and inflamed, and the

distant thunder. After a time, it rises a little above the horizon, to which its lower edge is parallel, and extremely black, and there remains stationary for a short time; when it is again put in motion, the most frightful flashes of forked lightning, accompanied by the heaviest possible claps of thunder, now issue from it in rapid succession; when it has reached a little beyond the zenith, a sudden chill is felt in the temperature, and then follows a more violent squall, or gust of wind, and rain, than the most fertile imagination can picture; but which seldom lasts longer than half an hour. I always made a practice of taking in every sail, and putting the ship before the wind: and I am of opinion that in some of the most violent, even without sail set, if that precaution was not taken, *any* ship would be thrown on her beam ends. On shore, all animated nature seems extinct; nothing is seen, nothing is heard; every creature, whether man, bird, or beast, having sought refuge and shelter from the approaching storm; but no sooner is it over than the air, which was before close and sultry, becomes so delightfully pure and invigorating as to reanimate the whole animal creation.

throat parched, and other exceedingly uncomfortable sensations excited, although it is generally said to give wounds and ulcers a strong predisposition to heal. The maximum of the thermometer is seldom above 75° Fahr. 10° lower than it is both before and after it. Its duration varies from two or three to seventeen or eighteen days; this may be considered as part of the fine season, which continues till the tornados again commence. It is not peculiar to this part alone, but prevails throughout the whole extent of tropical Africa.

The Gold Coast, which is said to commence at Cape Appollonia, but more properly at Cape Three Points, and ends at Cape Saint Paul, comes next in the line of coast; and as it differs both in height and appearance from that further to windward, so does it both in climate and salubrity.

The tornado season commences early in March, and ends about the middle of May; they are by no means either so violent or frequent as on the coast east or west of it. Towards their close, and immediately preceding the rains, strong southerly squalls with heavy rain are sometimes experienced, but unaccompanied by thunder and lightning.

About the middle of May, the first rains commence, and continue for six weeks. Europeans who have spent some years in the country, suffer much inconvenience from intermittent fever, but it is seldom attended with danger.

Early in the month of July, the first rains cease (it is here that cessation commences), and is followed by a dense fog which continues till August. During this period those persons who are not inured to the climate are subject to attacks of the bilious remittent fever, which often proves fatal; the season when this pestilential disease prevails is comparatively short, arising I imagine from the surface of the land being composed of a light sandy soil, which easily admits the water that falls to run off into the sea, or to be taken up by evaporation; it is a singular fact that there are no springs on the Gold Coast, and the inhabitants are entirely dependent on reservoirs, in which water is caught and preserved during the rains for the whole year's consumption.

From the beginning of August to the middle of September, the weather is particularly fine and pleasant, the mean temperature afloat not being more than 78° Fahrenheit.

To this succeeds the second rains, which last till the end of October, but these are so moderate as not to be more than occasional showers. The weather from this time is fine till the tornado season again commences. In December and January the harmatan occasionally blows as on the windward coast, and with the same effects.

The Bight of Benin,* from Cape Saint Paul to the river Ramos, is (with the exception of the tornados being much more

* The Bight of Benin is formed by Cape Saint Paul and Formosa, which are distant from each other about 103 leagues.

tempestuous), subject to the same periodical division of seasons as the Gold Coast till the middle of September, when the second rains set in with the greatest possible violence, frequently attended with the heaviest tornados. I also found that on the eastern side of it, from Lagos quite round over that alluvial land through which the great rivers flow, a slight tornado came off about sunset every evening during the month of November.

In the Bight of Biafra, the tornado season commences in the beginning of February, and lasts to the middle of March, when it is succeeded by the first rains. These continue to the middle of May, and are then followed to the end of that month by the fogs, but they are not nearly so dense as in the Bight of Benin, especially in the neighbourhood of the islands. From this time to the middle of September the weather is particularly fine, but seldom unaccompanied with haze. At the latter period, the second rains set in, and fall extremely heavily to the end of October, when they begin to subside, and are followed by fine weather till the tornados recommence in February.

The above description of the weather within the before-mentioned limits on the Coast of Africa, although it appears to be divided, and governed by laws with the most perfect regularity, is by no means to be considered as not subject to any variation; as, for example, in July, 1819, on the Gold Coast and Bight of Benin, although generally subject to fogs, I experienced a considerable quantity of rain till I reached the river Ramos, from thence around Cape Formosa, and into the Bight of Biafra, the weather was particularly fine although attended with some haze.

Again in the year 1820, I was cruizing in the Bight of Biafra during the whole of the months of June and July, and nothing could exceed the delightful state of the weather; but in the end of July, 1821, I rounded the Bight of Benin in a thick fog, and on approaching Cape Formosa, and running along the north coast of Biafra, I found heavy rains constantly falling from midnight to noon, which continued for nearly a month.

Also, although a portion of the year is called the tornado season, tornados are not uncommon during the periodical rains, insomuch that in the neighbourhood of Sierra Leone, the end of September is frequently called the second tornado season.

The following daily statement of the temperature is the mean of three observations of the thermometer taken generally at 8 a.m. 1 p.m. and 8 p.m.

The thermometer was hung against the middle partition of the Pheasant's cabin, with the doors, windows, and ports, always open to admit a free circulation of air.

1819.		1820.		1821.	
June 1	80¾°	June 1	79°	June 1	81°
2	82¼	2	80¼	2	80½
3	83¼	3	81	3	80¼
4	83¼	4	81½	4	81
5	82	5	81	5	80
6	82	6	[illegible]	6	81
7	81½	7	80½	7	79½
8	84½	8	79	8	79½
9	85	9	78½	9	79¾
10	84¾	10	79½	10	80
11	84¼	11	79½	11	79¾
12	83¾	12	78½	12	79½
13	83	13	78½	13	78¾
14	84¾	14	77¾	14	78½
15	82¾	15	77½	15	78¾
16	84¾	16	78	16	79
17	81¾	17	78¾	17	79
18	83¼	18	78	18	78
19	81¾	19	77¾	19	79.
20	82¾	20	76¾	20	78¾
21	81½	21	78½	21	78
22	79¾	22	76¾	22	78
23	81	23	77	23	77½
24	80¾	24	77	24	78
25	79½	25	76¾	25	77¾
26	79¼	26	76¾	26	77¾
27	78¾	27	77¾	27	76
28	78¾	28	77¼	28	75
29	[illegible]	29	77¾	29	77¾
30	80	30	78¼	30	78
Mean of the month ..	82	Mean of the month ..	78	Mean of the month..,	78¾
Maximum therm. on the 9th at 1 p. m...	87	Maximum therm. on the 4th at 1 p. m...	82	Maximum therm. on the 6th at 1 p. m...	85
Minimum therm. on the 29th at 8 a. m..	78	Minimum therm. on the 21st at 8 a. m..	75	Minimum therm. on the 26th at 8 a. m..	74

June, 1819.—From the 1st to 5th, between lat. 11° and 8° 30′ N, fine weather; the 6th and 7th off Sierra Leone, tornados and heavy rain; from the 7th to 17th at anchor in the river. Weather occasionally fine; at others showery, and tornados. From the 17th to 30th, on the coast between Sierra Leone and Cape Palmas, continued heavy rain, with heavy tornados occasionally.

June, 1820.—From the 1st to 16th, running from Cape Coast to the Island of Saint Thomas, north of the parallel of 3° N, a considerable quantity of rain fell; but south of it, had fine weather; from the 17th to 30th cruizing between the parallel of 2° N and the equator. Fine weather, but cloudy; and I must here observe, after three years' experience, that I have always found the weather more cloudy, and the thermometer lower, on or near the equator, than a few degrees north or south of it.

June, 1821.—From the 1st to 23d, at anchor at the Island of Ascension particularly fine weather. From the 24th to 30th, on the passage from Ascension to Cape Coast, fresh breezes, and cloudy throughout.

1819.		1820.		1821.	
July 1	80¾°	July 1	77½°	July 1	80°
2	79½	2	77¾	2	80
3	78¾	3	77¾	3	79½
4	79½	4	79	4	79¾
5	78½	5	77¾	5	79½
6	78	6	76½	6	78¾
7	78½	7	76½	7	77¾
8	78½	8	76½	8	77
9	79¾	9	75¾	9	78½
10	80	10	77	10	78½
11	79	11	77½	11	78¾
12	78¾	12	77½	12	78¾
13	79	13	77¾	13	78½
14	79¾	14	77¾	14	77¾
15	79	15	76¾	15	78
16	80	16	78	16	77
17	80	17	77	17	76½
18	81	18	77	18	76¾
19	80½	19	77½	19	78½
20	81½	20	77½	20	78
21	77¾	21	77	21	80
22	78½	22	77¾	22	80
23	78	23	77¾	23	79½
24	78¾	24	77½	24	79½
25	78½	25	77½	25	80
26	78	26	77¾	26	79¾
27	77¾	27	78½	27	79
28	77½	28	76	28	78½
29	78½	29	75½	29	78½
30	78¾	30	76¾	30	78¾
31	78¾	31	77	31	78½
Mean of the month...	79	Mean of the month...	77½	Mean of the month..	78¾
Maximum therm. on the 1st at 1 p. m. ..	82	Maximum therm. on the 4th at 1 p. m...	82	Maximum therm. on the 12th at 1, p. m.	82
Minimum therm. on the 21st, 23d, 26th, 27th, 28th at 8 a. m. and p. m.	77	Minimum therm. on the 7th, 8th, 9th, 15th, 29th, at 8 a. m.	75	Minimum therm. on the 17th at 8 p. m.	75

July, 1819.—From the 1st to 9th, from the vicinity of Cape Palmas to Cape Coast Roads, continued heavy rain. From the 10th to 16th at anchor in Cape Coast Roads, cloudy weather, with frequent showers. From the 17th to 20th on various other parts of the Gold Coast, fine weather. From the 21st to 25th, in the Bight of Benin, continued heavy rain. From the 26th to 31st, in the Bight of Biafra, fine weather.

July, 1820.—The whole of this month between 1° 50′ N, and 0° 20′ S, moderate and cloudy weather throughout.

July, 1821.—From the 1st to 18th on the Gold Coast, moderate breezes and hazy, with showers at times. From the 18th to 23d, rounding the Bight of Benin, in thick hazy weather. From the 24th to 31st, on the coast between Cape Formosa and the river Bonni, cloudy and unsettled weather, with rain, especially from midnight to noon.

1819.		1820.		1821.	
August 1	77⅔°	August 1	77°	August 1	79⅔
2	77⅓	3	75⅓	2	76
3	77⅔	2	76⅓	3	75
4	78	4	79	4	77⅔
5	76⅔	5	78⅔	5	77
6	78⅓	6	78	6	76
7	77⅔	7	77⅔	7	76
8	77⅔	8	79⅓	8	76⅔
9	77⅓	9	74⅔	9	77⅓
10	77⅔	10	74⅔	10	78⅔
11	76⅔	11	73	11	80
12	75	12	72⅔	12	79⅓
13	76⅔	13	72⅔	13	78⅔
14	78	14	73⅓	14	79
15	78⅓	15	73⅔	15	78⅓
16	79	16	74⅓	16	79
17	77⅔	17	75	17	79⅔
18	77⅔	18	74⅔	18	78⅓
19	77	19	74⅓	19	77
20	77⅓	20	72⅔	20	77
21	78⅓	21	73	21	78⅔
22	78⅔	22	73	22	78
23	78	23	72	23	79
24	77	24	73	24	77⅓
25	78	25	73⅓	25	77⅔
26	78⅓	26	73	26	77⅓
27	78⅓	27	73⅓	27	77⅔
28	78⅔	28	73	28	77
29	78⅓	29	75	29	78⅔
30	78⅔	30	76⅓	30	77⅓
31	79⅓	31	76	31	77
Mean of the month...	78	Mean of the month ..	74⅔	Mean of the month ..	77⅔
Maximum therm. on the 31st at 1 p. m.	80	Maximum therm. on the 8th at 1 p. m. .	80	Maximum therm. on the 1st at 1 p. m...	82
Minimum therm. on the 12th all day. ..	75	Minimum therm. on the 13th at 8 a. m. .	71	Minimum therm. on the 3d at 8 a. m. ..	74

August, 1819.—From the 1st to 17th, running from the Bight of Biafra to Sierra Leone; while in the neighbourhood of the equator, cloudy, but settled weather, with fresh southerly winds. After passing the lat. of 4° N (about the parallel of Cape Palmas), continued and heavy rain. From the 18th to 25th, at anchor in Sierra Leone River, heavy rain. From the 26th to 31st, between Sierra Leone and Cape Mount, cloudy weather, with rain occasionally.

August, 1820.—The whole of this month on the Gold Coast, the weather generally fine.

August, 1821.—From the 1st to 6th, at anchor in George's Bay, in the Island of Fernando Po, unsettled weather with rain. 7th, 8th, 9th, and 10th, in the vicinity of the above island, with a continuation of the same weather. From the 11th to 31st, between the parallels of 1° and 3° N, and 8° and 4° E, variable and unsettled weather, frequently attended with rain.

1819.		1820.		1821.	
September 1	79°	September 1	75⅕°	September 1	76°
2	79	2	73⅕	2	75⅕
3	79⅕	3	76⅖	3	75⅖
4	79	4	76⅕	4	75⅕
5	78⅖	5	77⅕	5	75⅗
6	78⅕	6	77⅗	6	76
7	78⅕	7	78⅕	7	78
8	78⅕	8	78	8	80
9	76⅗	9	78⅕	9	79⅖
10	75⅕	10	78	10	79⅕
11	77⅕	11	77⅕	11	80⅗
12	79	12	78	12	80⅕
13	76⅕	13	78	13	79⅖
14	76⅕	14	77⅖	14	80
15	76⅖	15	78	15	80⅗
16	76	16	78⅖	16	78⅗
17	75⅖	17	79	17	80
18	76⅕	18	78⅗	18	79⅗
19	74⅕	19	78⅖	19	79⅖
20	77	20	79	20	79
21	78	21	76	21	78
22	77	22	77⅖	22	79⅗
23	77⅖	23	77⅖	23	79
24	78⅕	24	79	24	79⅗
25	78	25	79⅕	25	80
26	79⅕	26	79⅖	26	81
27	80	27	79⅖	27	78⅕
28	78⅖	28	78⅖	28	78⅕
29	79⅕	29	78⅖	29	79⅕
30	79⅕	30	78⅕	30	79⅕
Mean of the month . .	77⅗	Mean of the month . .	78	Mean of the month . .	78⅗
Maximum therm. on the 27th at 1 p. m. .	81	Maximum therm. on the 27th at 1 p. m.	80	Maximum therm. on the 26th at 1 p. m.	83
Minimum therm. on the 19th at 8 p. m. .	74	Minimum therm. on the 2d at 8 p. m. . .	72	Minimum. therm. on the 4th at 8 a. m. .	74

September, 1819.—From the 1st to 10th, running from the windward coast to Cape Coast Roads, moderate and cloudy weather, with showers of rain occasionally. From the 11th to 16th, at anchor in Cape Coast Roads, fine weather. On the 17th, 18th, 19th, and 20th, between the parallels of 5° and 6° N, cloudy weather. From the 21st to 30th in the Bight of Benin, continued and heavy rain.

September, 1820.—From the 1st to 12th, reaching from the Gold Coast to the Bight of Biafra, moderate and cloudy weather. From the 13th to 30th, between the parallels of 2° N and equator, first week cloudy, with rain occasionally; latter part heavy rain.

September, 1821.—From the 1st to 9th, running from 0° 30′ N, and the meridian towards Sierra Leone, moderate and fine weather. From the 10th to 30th, at anchor in Sierra Leone River, weather extremely unsettled, with a considerable quantity of rain.

1819.		1820.		1821.	
October 1	79°	October 1	78⅓°	October 1	79⅓°
2	79	2	78⅔	2	79⅓
3	79	3	78⅔	3	82
4	78⅓	4	78	4	81⅔
5	79	5	77⅓	5	79
6	78⅔	6	78	6	80⅓
7	79⅔	7	78⅔	7	82
8	78⅔	8	78⅓	8	81
9	79⅓	9	78	9	80⅔
10	79	10	78⅔	10	78⅓
11	79⅓	11	78	11	80
12	79⅔	12	78⅓	12	81⅔
13	79	13	77⅔	13	79⅓
14	80⅔	14	78	14	79
15	81	15	78	15	81⅓
16	80⅔	16	77⅔	16	81
17	78⅔	17	77⅓	17	80
18	80	18	77	18	80⅓
19	79⅓	19	77⅓	19	81⅓
20	79⅓	20	77⅓	20	83⅓
21	81	21	77⅔	21	83⅔
22	81⅓	22	79	22	82⅓
23	80⅓	23	79⅔	23	82⅔
24	80⅔	24	77⅔	24	83
25	79⅔	25	80⅔	25	83⅔
26	80	26	80⅔	26	81⅓
27	80⅔	27	81⅔	27	83⅔
28	81	28	81	28	83⅓
29	81	29	79⅓	29	81⅔
30	81⅓	30	81⅔	30	83⅓
31	81⅓	31	78⅓	31	83⅓
Mean of the month ..	80	Mean of the month ..	78⅔	Mean of the month ..	81⅔
Maximum therm. on the 30th at 1 p. m.	82	Maximum therm. on the 30th at 1 p. m.	84	Maximum therm. on the 25th at 1 p. m.	86
Minimum therm. on the 5th at 8 a. m...	77	Min. therm. on 24th at 1 p. m. a tornado	76	Minimum therm. on the 10th at 8 a. m.	77

October, 1819.—From the 1st to 25th, cruizing in front of the Bight of Benin, nearly the whole time between the parallels of 4° and 5° N, continued and most heavy rain. The remainder of the month on the Gold Coast, fine weather.

October, 1820.—From the 1st to 13th, between the parallels of 1° 20′ N and equator, and 9° and 3° 30′ E, continued and heavy rain. From 14th to 23d, between the parallels of the equator and 4° N and 3° E. and 13° W, cloudy weather. From the 24th to 31st, between the parallels of 5° and 8° 30′ N, and 13° and 14° 30′ W, continued and heavy rain.

October, 1821.—From the 1st to 16th, cruizing between the parallels of 8° and 6° N, and 12° and 14° W, extremely unsettled and squally weather, attended by heavy and frequent rain. From the 17th to 31st, cruizing between the parallels of 6° 30′ and 11° 30′ N, and 14° and 19° W, light winds, calms, and fine weather.

1819.		1820.		1821.	
November 1	82°	November 1	80⅓°	November 1	84°
2	82	2	80	2	84
3	82⅓	3	80⅓	3	84⅓
4	82⅔	4	80⅓	4	84
5	82⅔	5	80⅓	5	83⅓
6	82	6	80	6	83⅔
7	83	7	80⅔	7	83
8	83⅔	8	80⅓	8	82⅓
9	84	9	81	9	82⅓
10	82⅔	10	79⅔	10	80⅓
11	83	11	79⅔	11	80
12	82⅓	12	80⅔	12	80
13	82⅓	13	80⅓	13	78⅔
14	83	14	80⅔	14	78⅓
15	82⅔	15	79	15	79⅓
16	82⅓	16	82⅔	16	81⅔
17	80	17	82	17	81⅓
18	83⅔	18	80	18	81⅓
19	84	19	81⅓	19	81⅓
20	83⅔	20	81	20	82⅓
21	83	21	82⅓	21	83
22	82⅔	22	81	22	84
23	83	23	80⅓	23	83⅔
24	81⅓	24	81	24	84
25	80⅔	25	80⅔	25	84⅔
26	82⅓	26	81⅔	26	84⅓
27	83⅓	27	82	27	84
28	83⅓	28	81	28	83⅓
20	83⅓	29	81⅓	29	84⅓
30	81⅔	30	82⅓	30	84
Mean of the month ..	82⅔	Mean of the month ..	80⅔	Mean of the month...	82⅓
Maximum therm. on the 19th at 1 p. m..	85	Maximum therm. on the 16th at 1 p. m..	84	Maximum therm. on the 29th at 1 p. m..	87
Minimum therm. on the 17th at 8 a. m..	78	Minimum therm. on the 10th at 8 a. m..	77	Minimum therm. on the 14th at 8 a. m..	76

November, 1819.—The whole of this month, between the parallels of 6° and 3° N, and 1° and 6° E, generally fine weather, but a few tornados.

November, 1820.—The whole of this month, in the vicinity of Sierra Leone, during the first 16 days a considerable quantity of rain fell. The last fortnight the weather was cloudy, but otherwise fine.

November, 1821.—Throughout the whole of this month cruizing between the Island of Goree and river Sierra Leone, the weather particularly fine, but frequently attended with considerable haze.

1819.		1820.		1821.	
December 1	81¾°	December 1	81½°	December 1	82°
2	81¼	2	82	2	81½
3	83¼	3	81¾	3	80½
4	82¼	4	81¼	4	80¾
5	79¾	5	80	5	80¾
6	80	6	80	6	81½
7	78¼	7	81¾	7	81
8	80¼	8	81	8	80
9	82¼	9	79	9	80
10	79	10	80¼	10	80
11	78¾	11	81	11	80½
12	79¼	12	80¾	12	79¾
13	78¾	13	80¾	13	81⅔
14	79	14	80¾	14	80¼
15	82	15	80¼	15	80¼
16	82¾	16	81¼	16	80
17	82¾	17	81½	17	79¾
18	83¾	18	80¾	18	79
19	83	19	81	19	78
20	81¾	20	81	20	78
21	80	21	82	21	78
22	81½	22	81	22	77¾
23	78	23	80	23	79¼
24	80½	24	79¼	24	79¾
25	82	25	78¾	25	79¾
26	79¾	26	80¼	26	80¾
27	82½	27	78¼	27	80¾
28	83	28	79¼	28	80½
29	83½	29	79½	29	78¾
30	82½	30	79¾	30	79¾
31	82½	31	80¼	31	79
Mean of the month ..	81	Mean of the month ..	80¼	Mean of the month ..	79¾
Maximum therm. on the 9th at 1 p. m. .	86	Maximum therm. on the 4th at 1 p. m. .	84	Maximum therm. on the 7th at 1 p. m. .	85
Minimum therm. on the 10th at 8 a. m. .	77	Minimum therm. on the 25th at 8 a. m.	75	Minimum therm. on the 19th at 8 a. m.	75

December, 1819.—From the 1st to 14th, in and near Princes Island, fine weather. From the 15th to 31st, between the parallels of 1° 30′ and 4° 57′ N, running from Princes Island to Cape Coast Roads, moderate and cloudy weather; between the 19th and 24th, squally at times.

December, 1820.—From the 1st to 16th, between Sierra Leone and Cape Palmas, the weather very unsettled and squally with rain. From the 17th to 23d, between Cape Palmas and Cape Coast; and from the 24th to 31st, at anchor at the latter place, weather generally fine and pleasant.

December, 1821.—The whole of this month at anchor in Sierra Leone River. From the 1st to 13th, regular sea and land breezes, with fine weather. From the 14th to 23d, a strong harmatan blowing, with thick hazy weather. From the 24th to 31st, light and regular sea and land breezes, with fine weather, but rather hazy.

1820.		1821.		1822.	
January 1	$82\frac{2}{5}$°	January 1	$80\frac{2}{5}$°	January 1	$77\frac{2}{5}$°
2	83	2	$80\frac{3}{5}$	2	$78\frac{3}{5}$
3	$82\frac{2}{5}$	3	$80\frac{2}{5}$	3	81
4	$82\frac{3}{5}$	4	$81\frac{1}{5}$	4	$80\frac{1}{5}$
5	83	5	$81\frac{1}{5}$	5	$80\frac{1}{5}$
6	$82\frac{1}{5}$	6	$81\frac{1}{5}$	6	$80\frac{1}{5}$
7	$81\frac{2}{5}$	7	$79\frac{2}{5}$	7	$81\frac{1}{5}$
8	$81\frac{3}{5}$	8	82	8	81
9	$81\frac{1}{5}$	9	$82\frac{1}{5}$	9	81
10	$80\frac{1}{5}$	10	$82\frac{3}{5}$	10	$81\frac{1}{5}$
11	80.	11	83	11	81
12	$79\frac{3}{5}$	12	$82\frac{1}{5}$	12	$81\frac{1}{5}$
13	$80\frac{1}{5}$	13	$81\frac{2}{5}$	13	$81\frac{1}{5}$
14	$80\frac{3}{5}$	14	$80\frac{3}{5}$	14	82
15	$81\frac{3}{5}$	15	$81\frac{1}{5}$	15	78
16	82	16	82	16	$80\frac{1}{5}$
17	$82\frac{1}{5}$	17	$82\frac{1}{5}$	17	$80\frac{1}{5}$
18	$80\frac{2}{5}$	18	82	18	$80\frac{1}{5}$
19	$80\frac{1}{5}$	19	82	19	$81\frac{3}{5}$
20	$81\frac{2}{5}$	20	$81\frac{2}{5}$	20	82
21	$80\frac{2}{5}$	21	$81\frac{3}{5}$	21	$80\frac{2}{5}$
22	81	22	83	22	79
23	$78\frac{3}{5}$	23	$81\frac{1}{5}$	23	80
24	$80\frac{2}{5}$	24	80	24	79
25	$81\frac{1}{5}$	25	$81\frac{1}{5}$	25	$78\frac{1}{5}$
26	82	26	81	26	79
27	$83\frac{1}{5}$	27	82	27	$77\frac{1}{5}$
28	$82\frac{3}{5}$	28	81	28	$78\frac{3}{5}$
29	$82\frac{4}{5}$	29	$82\frac{1}{5}$	29	$78\frac{1}{5}$
30	$82\frac{4}{5}$	30	$82\frac{3}{5}$	30	80
31	$82\frac{1}{5}$	31	81	31	80
Mean of the month...	$81\frac{3}{5}$	Mean of the month ..	$81\frac{2}{5}$	Mean of the month ..	80
Maximum therm. on the 27th at 1 p. m.	84	Maximum therm. on the 29th at 1 p. m.	86	Maximum therm. on the 20th at 1 p. m..	85
Minimum therm. on the 23d at 8 a. m..	77	Minimum therm. on the 31st at 8 a. m. .	77	Minimum therm. on the 1st at 8 a. m...	75

January, 1820.—From the 1st to 18th, on the Gold Coast, moderate and settled weather. From the 19th to 31st, cruizing between the parallels of 4° and 5° N, in front of the Bight of Benin, continued fine weather.

January, 1821.—From the 1st to 7th, on the Gold Coast, moderate and fine weather. From the 8th to 23d, between the parallels of 3° 30′ and 4° N, and 1° 30′ and 7° 30′ E, light winds and fine weather attended by considerable haze. From the 24th to 31st, near the Island of Fernando Po, and at anchor in the Bay, light winds and fine weather; while at anchor in this Bay, found a greater variation of the temperature between the night and day than any part of the coast I had visited, the range being 9° or 10°.

January, 1822.—The whole of this month in Sierra Leone River; the weather in general moderate, but a slight tornado or two towards the middle of it.

1820.		1821.	
February 1	83°	February 1	82°
2	83⅛	2	81⅛
3	83⅜	3	81
4	83⅛	4	82⅛
5	83	5	82⅛
6	83⅛	6	82⅞
7	82⅞	7	82⅜
8	84⅛	8	81⅛
9	84⅛	9	82⅛
10	84	10	83⅛
11	82⅞	11	83
12	84	12	82⅞
13	82⅞	13	83⅝
14	83	14	83⅛
15	82⅞	15	82⅞
16	83⅛	16	82⅝
17	84	17	83
18	84	18	83⅝
19	83⅛	19	83⅛
20	83⅜	20	84
21	84⅛	21	84
22	83	22	84
23	83	23	84
24	83	24	84
25	81⅞	25	84
26	83	26	83⅝
27	83⅛	27	82
28	84⅛	28	83⅜
29	84	Mean of the month . .	83
Mean of the month . .	83⅛	Maximum therm. on the 1st at 1 p. m. .	86
Maximum therm. on the 9th at 1 p. m. .	86	Minimum therm. on the 1st at 8 a. m. .	78
Minimum therm. on the 15th at 8 a. m. .	81		

February, 1820.—Throughout this month, cruizing between the parallels of 4° and 6° N, and 3° and 5° E, generally fine weather.

February, 1821.—Nearly the whole of this month between the parallels of 2° 30′ N and the equator, and 8° 30′ and 1° 30′ E, light winds and cloudy, but fine weather throughout.

1820.		1821.	
March 1	83⅗°	March 1	83⅗°
2	81⅖	2	83⅗
3	81⅗	3	83⅕
4	82⅖	4	82⅕
5	82⅕	5	83
6	82	6	83
7	80⅕	7	82⅕
8	82	8	81
9	84	9	81⅗
10	84	10	82
11	81⅕	11	82⅕
12	83	12	81⅕
13	80⅗	13	82⅕
14	82⅗	14	82⅗
15	84	15	82⅕
16	81	16	79⅗
17	82⅕	17	81
18	82⅕	18	82
19	80⅕	19	82
20	82	20	81⅕
21	83⅕	21	83⅕
22	83	22	83⅕
23	83	23	82
24	81	24	83⅕
25	82⅗	25	83
26	84⅕	26	82⅗
27	83⅖	27	83⅕
28	82⅕	28	83⅖
29	84⅕	29	83⅗
30	83⅖	30	82⅖
31	81⅕	31	82⅕
Mean of the month...	82⅕	Mean of the month...	82⅕
Maximum therm. on the 26th at 1 p. m.	86	Maximum therm. on the 1st at 1 p. m...	85
Minimum therm. on the 31st at 8 p. m.	78	Min. therm. on 16th at 1 p. m. a tornado	79

March, 1820.—From the 1st to 7th, in and near Princes Island, in general, fine weather, but sometimes squally. From the 8th to 28th, between the parallels of 2° and 5° 30′ N, and 7° 30′ and 2° E; the remainder of the month on the Gold Coast; generally fine weather; between the first periods had a few tornados.

March, 1821.—From the 1st to 7th, between the parallels of 2° N and 1° 21′ E, and the Gold Coast, moderate and fine weather. From the 8th to 21st, on the Gold Coast, fine weather. From the 22d to 31st, between the parallels of 3° 30′ and 1° 30′ N, and 1° and 7° E, moderate and pleasant weather.

1820.		1821.	
April 1	83°	April 1	82⅔°
2	83⅓	2	83⅔
3	84	3	83⅓
4	85⅔	4	79⅓
5	86⅓	5	82⅓
6	85	6	82⅓
7	84	7	80⅔
8	84⅓	8	82⅓
9	83⅓	9	82
10	84⅔	10	83
11	84	11	84
12	82⅓	12	83⅓
13	83⅓	13	81
14	83⅔	14	82⅔
15	83	15	80
16	79⅔	16	82
17	82⅓	17	80⅔
18	81	18	82⅓
19	81⅔	19	83⅓
20	80⅔	20	83
21	80⅔	21	83⅓
22	80	22	82
23	80	23	82⅔
24	79⅔	24	83
25	79⅓	25	82⅔
26	80⅔	26	82
27	81	27	83
28	80⅓	28	83
29	81	29	83⅔
30	82	30	84⅓
Mean of the month ..	82⅓	Mean of the month ..	82⅓
Maximum therm. on the 4th at 1 p. m. ..	88	Maximum therm. on the 30th at 1 p. m.	86
Min. therm. on 16th at 1 p. m. a tornado	77	Minimum therm. on the 4th at 8 p. m.	78

April, 1820.—From the 1st to 24th, running from the Gold Coast to the Island of Ascension, between the coast and equator experienced frequent and heavy tornados; and between the parallel of 3° N and the latter had continued and heavy rain. Crossed the meridian and equator on the 16th nearly at the same time, after which had strong southerly and SSE winds, with cloudy weather, all the way to Ascension. The remainder of the month at anchor at Ascension fine weather.

April, 1821.—From the 1st to 11th, in the vicinity of Princes Island, experienced several tornados; otherwise had fine weather. From the 12th to 20th, running from Princes Island to the Gold Coast, experienced frequent and heavy tornados. From the 21st to 30th, on the Gold Coast, fine weather, with the exception of a tornado at times.

1820.			1821.		
May	1	82½°	May	1	83°
	2	82		2	84½
	3	83		3	83
	4	82¼		4	81¼
	5	83¼		5	80
	6	82¾		6	82¼
	7	81		7	82¼
	8	81¾		8	82¾
	9	79½		9	80¾
	10	79½		10	82¾
	11	79¾		11	82¼
	12	81¾		12	82¼
	13	80¾		13	[illegible]½
	14	80¾		14	81¾
	15	81¼		15	81¾
	16	80½		16	81¾
	17	80¼		17	80¾
	18	80		18	80¼
	19	79¾		19	80½
	20	80		20	80¾
	21	79		21	80¼
	22	78½		22	80¾
	23	77½		23	80¼
	24	79¾		24	80¼
	25	80¼		25	79½
	26	80¾		26	80
	27	81¾		27	80¾
	28	82		28	81¼
	29	83		29	81¼
	30	82¾		30	80¼
	31	81		31	80¼
Mean of the month ..		81	Mean of the month ..		81¾
Maximum therm. on the 4th at 1 p. m..		83	Maximum therm. on the 2d at 1 p. m. ..		86
Min. therm. on 23d at 8 a. m. on equator. .		77	Minimum therm. on the 25th at 8 a. m.		78

May, 1820.—From the 1st to 16th, at anchor at Ascension, fine clear weather. From the 17th to 31st, running from Ascension to Cape Coast Roads. While south of the equator, had strong breezes and cloudy weather. On approaching the coast, experienced unsettled weather, with rain.

May, 1821.—From the 1st to 7th, at anchor in Cape Coast Roads, cloudy weather, with rain occasionally. From the 8th to 14th, between the Gold Coast and equator, variable weather, sometimes fine, at others rainy. From the 15th to 26th, between the equator and the Island of Ascension. On the 27th, anchored at the latter; fine weather throughout.

Article X.

On the Height of the Barometer. By M. P. Moyle, Esq.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Helston, April* 15, 1823.

A proper collection of accurate barometrical observations would give us a correct idea of the height of the different places where they are kept above the level of the sea, as well as serving other useful purposes; but unless every necessary correction is made, this cannot be obtained. From the few observations that I have made on those tables which have appeared in the *Annals,* this consideration does not seem to have been properly meditated. It may not, therefore, be unacceptable to such of your correspondents to make a few remarks on this particular point, and thereby prove its necessity.

It is well known that mercury expands by heat, and contracts on the application of cold. Hence the height of the mercurial column in the barometer is affected not only by the pressure of the atmosphere, but by the temperature, and the attention of meteorologists ought to be more fully drawn to this consideration to render their tables of the greatest utility.

The standard temperature for observation is agreed on all hands to be 32° of Fahr.; consequently if made at a time when the thermometer stands above or below this point, it must of necessity indicate a higher or lower range respectively; and to prove the extent of error arising from the neglect of this circumstance, let us suppose that the height of 30 inches of mercury is taken when the attached thermometer stands at 72°; this would give an excess above what it would be at 32° of more than $\frac{\cdot 13}{100}$ths of an inch from the mere expansion of the mercury. No wonder then that errors arise in our calculations.

General Roy found that the expansion of one inch of mercury in the barometer tube at 32° was ·0001127: hence to reduce the observed height of the mercury to what it would be at 32°, becomes an easy matter; but for the greater facility, I have constructed the following table, which represents the expansion of one inch of mercury for its corresponding temperature. It extends from 32° to 150° beyond which it is not probable that any observation will be made.

In order to obtain the exact temperature of the mercury, the observation should be made by a thermometer attached to the frame of the barometer, that it may warm and cool along with it.

32°	·0001127	62°	·0032910	92°	·0064020	122°	·0093030
33	·0001127	63	·0033976	93	·0065026	123	·0094276
34	·0002250	64	·0035040	94	·0066030	124	·0095220
35	·0003370	65	·0036102	95	·0067032	125	·0096162
36	·0004492	66	·0037162	96	·0068032	126	·0097102
37	·0005610	67	·0038220	97	·0069030	127	·0098040
38	·0006726	68	·0039276	98	·0070026	128	·0098976
39	·0007840	69	·0040330	99	·0071020	129	·0099910
40	·0008952	70	·0041382	100	·0072012	130	·0100862
41	·0010062	71	·0042432	101	·0073002	131	·0101772
42	·0011170	72	·0043480	102	·0073990	132	·0102700
43	·0012276	73	·0044526	103	·0074976	133	·0103626
44	·0013380	74	·0045570	104	·0075960	134	·0104550
45	·0014482	75	·0046612	105	·0076942	135	·0105472
46	·0015592	76	·0047652	106	·0077922	136	·0106392
47	·0016680	77	·0048690	107	·0078900	137	·0107310
48	·0017776	78	·0049726	108	·0079876	138	·0108226
49	·0018870	79	·0050760	109	·0080850	139	·0109140
50	·0019962	80	·0051792	110	·0081822	140	·0110052
51	·0021052	81	·0052822	111	·0082772	141	·0110962
52	·0022140	82	·0053850	112	·0083760	142	·0111870
53	·0023226	83	·0054376	113	·0084726	143	·0112776
54	·0024310	84	·0055900	114	·0085690	144	·0113680
55	·0025392	85	·0056922	115	·0086652	145	·0114582
56	·0026472	86	·0057942	116	·0087612	146	·0115482
57	·0027550	87	·0058860	117	·0088570	147	·0116380
58	·0028626	88	·0059976	118	·0089526	148	·0117276
59	·0029700	89	·0060990	119	·0090480	149	·0118170
60	·0030772	90	·0062002	120	·0091432	150	·0119062
61	·0031842	91	·0063012	121	·0092380		

There are different ways to calculate the correction from this table; the first, and most accurate, is, that of multiplying the sum in the table corresponding with the observed temperature by 30, which gives the expansion for 30 inches of mercury. Then let the observed height of barometer be 28·420, attached thermometer 72°, and we shall have 4348 × 30 = 13044. Then 30·13044 : 30 : : 28·420 = 28·29697.

The second, the one I always adopt, as being more expeditious, is by multiplying the sum corresponding with the temperature by the observed height of mercury, and then taking it from the observed height, viz. 4348 × 28·42 = 1·2357 − 28·420 = 28·29643, differing a mere nothing from the first method.*

It appears from the Ann. de Chim. et Phys. that the meteorological table published monthly in them has the proper correc-

* The correction obtained by this method must be *added* to or *subtracted* from the observed heights, according as the temperature is below or above the standard temperature, or 32° of Fahr.

tion made, and that it is marked at nine in the morning, at noon, at three in the afternoon, and at nine at night.

From the monthly mean of these heights, it appears that the barometer is highest at nine in the morning, next highest at nine in the evening, lower at noon, and lowest of all at three in the afternoon. The proper hours, therefore, for taking the heights of the barometer is nine in the morning, and at three in the afternoon.

The elevation of the barometer above the level of the sea ought also to be noted when known; and if a correction is made for it in the results given, it should also be remarked, as some meteorologists allow for it, while others are guilty of the omission. I am, dear Sir, your humble servant,

M. P. Moyle.

Article XI.

Some Particulars regarding the Ashmolean Catalogue of Extraneous Fossils, published in Latin by Mr. Edward Luid (or Llwyd); and recommending a Translation of the same to be made and printed. By Mr. John Farey.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Howland-street, March* 29, 1823.

In pursuance of a design which I formed some years ago, of collecting as many as possible of the published *localities* of fossil shells, and of other organic remains, in some instances, I lately made an alphabetical arrangement of the 294 *places*, to which Mr. *Edward Luid* (or Llwyd) seems to me to refer, in the second edition of his descriptive *Catalogue* of the *Ashmolean Museum* at Oxford, printed in 1760. This book I borrowed of my friends Messrs. Sowerby, having, after many years inquiry, never been able to meet with a copy of it on sale, from whence I conclude that it is out of print, and become very scarce and dear; which circumstances induce me to request you to give insertion in the *Annals* to a few particulars regarding Mr. Luid's work, with the hope that the same may excite the attention of the collectors of fossil shells, &c. and prove of some use to them, and may lead to the publishing of an English edition of this work, by some gentleman connected with the University; wherein I hope, that the copper plates to Mr. L.'s book are preserved, and might serve for a cheap English edition.

The specimens of organic remains, &c. mentioned, and briefly described, by Mr. Luid, including some sparry substances at the beginning, seem about 1800 in number; 1766 of which specimens are distinguished by a series of *numbers*, and some others

are interpolated, and marked *a*, *b*, *c*, &c. in addition to the number.

The local index which I have made shows, that 30 places, which I shall mention presently, furnished more than one-half of the whole collection, or 1065 of the specimens enumerated; consisting of 477 fossil shells, and 588 other bodies, mostly organized; the produce, apparently, of twelve of the assemblages of strata, ascertained by Mr. William Smith, and enumerated in his Geological Table, from the *London clay* downwards to the *lias*.

It hence appears, that 25 of the places, among the most productive of Ashmolean specimens, furnished none to the Smithean collection, of about 1155 specimens of shells, &c. which Mr. S. in June, 1816, deposited in the *British Museum*,* whose localities, he has partly mentioned in two quarto works, "Strata Identified," and a "Stratigraphical System" (but which works, unfortunately, remain unfinished); and which localities, as far as they have been published, are enumerated in alphabetical order, in the "Philosophical Magazine," vol. 50, p. 271.

For the purpose of ascertaining *the strata* of the following places, I have consulted Mr. Smith's separate "Geological County Maps," except as to Lincoln and Northampton counties, which are not yet published, and as to which, I have consulted his original "Geological Map of England," published in September, 1815; which last was accompanied by an interesting "Memoir," which has, I think, been strangely overlooked, by almost every subsequent writer.

1. From the *London clay*, on the N shore of Sheppy Island, near Minster, in Kent, 5 shells and, in all, 25 specimens, are described by Mr. Luid.

2. From the *Portland rock*, at Brill, 10 miles W of Aylesbury, Bucks, 11 shells and 2 other specimens.

3. From the *Coral rag* and pisolite, at 6 places; which, beginning south-westward in the range of these strata are as follows, viz. Faringdon, 13 miles W of Abingdon, Berks, 29 shells and 89 others; these 118 specimens being the greatest number from any one place; Garford (or Garvord) 4 miles W by S of Abingdon, Berks, 9 shells and 26 others; Marcham, 2½ miles W by S of Abingdon, Berks, 40 shells and 54 others; Bessel's-Leigh (or Basil's L.) 3 miles NW of Abingdon, Berks, 16 shells and 10 others; Chawley, 4¼ miles N by W of Abingdon, Berks, 5 shells and 13 others; and Stanton (St. John's) 3 miles NE of Oxford, 5 shells and 11 other specimens.

4. From the *Woburn sand*, at 3 places, viz. Cumner, 4¾ miles N by W of Abingdon, Berks, 6 shells and 10 others; Bullington, 1½ mile SE of Oxford, 28 shells and 28 others; and Stafford Grove, 2½ miles ENE of Oxford, 2 shells and 11 other specimens.

* See vol. xi, p. 364 of the First Series of the *Annals*, also the Phil. Mag. vol. li. p. 180. The places common to both collections are, Kelloways B.; Marsham; Sheppy I.; Stonesfield; and Towcester.

5. From the *Clunch clay*, at 2 places, viz. Oxford city, Sunk Fences or Walks, &c. 19 shells and 7 others; and Cowley, ½ mile SSE of Oxford, 41 shells and 27 other specimens.

6. From *Kelloway's stone*, at Kelloway's Bridge (or Calloway B.), 2 miles NE of Chippenham, Wilts, 13 shells.

7. From the *Cornbrash*, at 5 places, viz. Witney, 4 miles NNE of Bampton, Oxfordshire, 46 shells and 63 others; Kidlington, 2¼ miles SE of Woodstock, Oxfordshire, 21 shells and 13 others; Islip, 4 miles SE of Woodstock, Oxfordshire, 13 shells and 13 others; Charlton, 3 miles S of Bicester, Oxfordshire, 5 shells and 24 others; and Raunds (or Rance), 3½ miles S of Thrapston, Northamptonshire, 10 shells and 10 other specimens.

8. From the *Forest Marble* at Stonesfield (or Stunsfield), 2¼ miles W of Woodstock, Oxfordshire, 6 shells and 51 other specimens.

9. From the *Upper Oolite*, at 3 places, viz. Towcester (or Tocester), 8 miles SSW of Northampton, 9 shells and 6 others; Wellingborough, 6½ miles S of Kettering, Northampton, 7 shells and 6 others; and Desborough, 4½ miles NW of Kettering, Northamptonshire, 8 shells and 16 other specimens.

10. From the *Fuller's-earth*, at Marston Trussel (or Merston T.), 11½ miles WNW of Kettering, Northamptonshire, 13 shells and 11 other specimens.

11. From the *Under Oolite*, at 4 places, viz. Birlip Hill, 5 miles ESE of Gloucester, 9 shells and 4 others; Barrington (Great?) 5 miles E of Northleach, Gloucestershire, 22 shells and 12 others; Upton, ¾ mile W of Burford, Oxfordshire, 7 shells and 9 others; and Byfield, 6½ miles SW of Daventry, Northamptonshire, 21 shells and 3 other specimens.

12. From the *Lias*, at 2 places, viz. Parton Passage (or Pyrton P. on the W shore of Severn River), 4 miles SSW of Newnham, Gloucestershire, 23 shells and 28 others; and Whitton (on S shore of Humber River), 10 miles W of Barton, Lincolnshire, 28 shells and 11 other specimens are described, and part of them figured, by Mr. Luid; 56 of which latter are shells.

Five out of the above 30 places, the least production of shells, &c. have furnished Mr. L. with 13 specimens each; all the other 264 places mentioned in his work, gave less numbers than 12 specimens each to the Ashmolean collection, except, perhaps, some of those unnamed places, included under the respective county names.

In a new edition of Luid, I beg to suggest that the several *specimens figured*, should be pointed out by a reference to the number of the plate or *table*. The want of these references, and the apparently random placing of the figures in the plates, are at present very perplexing; and, lastly, I request, that an index to the several *localities* may accompany such edition, towards the preparing of which, I would gladly lend assistance; and am,

Yours, &c. JOHN FAREY.

Article XII.

A Description of the Crystalline Form of some new Minerals. By H. J. Brooke, Esq. FRS. FLS. &c.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *April* 19, 1822.

Having lately been engaged in an examination of the crystalline forms of minerals, and in a few instances of their chemical characters, preparatory to a list I have proposed to add to an elementary introduction to crystallography, I have observed a few new results, which form the substance of the following brief notices:

Arfwedsonite.—The benefits which mineralogy has derived from the labours of Mr. Arfwedson have induced me to associate his name with this mineral, which is from Greenland, and is black and foliated, and has been hitherto called ferriferous hornblende. It differs, however, from hornblende in its angles, its specific gravity, and its hardness.

I am not aware of its occurrence in determinable crystalline forms. It has cleavages parallel to the lateral planes, and to both the diagonals of a rhombic prism of 123° 55′, but there is no transverse cleavage to determine whether this prism is right or oblique.

Its colour is black without a shade of green. Its cleavage planes, and its cross fracture, have a greater lustre than those of amphibole, and it is scratched by amphibole.

Specific gravity 3·44.

It sometimes accompanies the sodalite from Greenland.

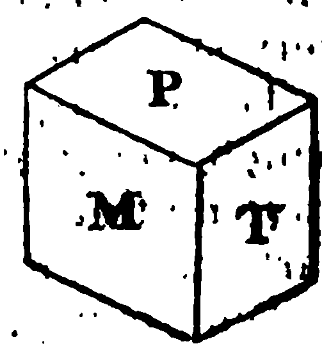
Cleavelandite.—The *albite,* and the *siliceous spar* of Haussman, which accompanies the green and red tourmaline from Chesterfield, in Massachusetts, are varieties of the same mineral. Two different names having been given to this substance, it becomes necessary either to adopt one of these to the exclusion of the other, or to assign a new one to the species.

As the *albite* is generally *blue,* and sometimes *red,** its name is consequently bad, and *siliceous spar* might be applied with equal propriety to other substances; I have, therefore, preferred adopting the term *Cleavelandite* to denote the species, out of respect to the Professor of Natural Philosophy in Bowdoin College, United States.

This species has cleavages in three directions, parallel to the planes of a doubly oblique prism.

* The specimen which first enabled me to determine the form is bright blue. It came from Labrador, and was given me by the Rev. C. I. Latrobe. M. Nordenskiold has favoured me with a specimen which is red.

P on M.	119°	30′
P on T.	115	0
M on T	93	30



Zoizite is crystallographically, as well as chemically, a distinct species of mineral. It has been classed by the Abbé Haüy under epidote, a mistake into which he has probably fallen from observing crystals of epidote apparently forming part of the mass of the specimens of zoizite from Carinthia.

Some specimens of it have been sent to this country from the Tyrol under the name of spodumene, and resembling that mineral in colour, and it probably accompanies the true spodumene from that locality.

A mineral called zoizite from the Oural Mountains, which has been examined chemically by Mr. Children, and found to agree in its characters with zoizite, has afforded the most accurate measurements of the prism. And Mr. Heuland has kindly supplied me with other specimens of this mineral, by means of which I have been enabled to ascertain that the angles of the prism are the same in specimens from all the different localities in which the mineral occurs.

Its form is a rhombic prism, probably oblique from an obtuse edge, the lateral planes measuring 116° 30′, with a bright cleavage plane parallel to the short diagonal of the prism.

Arseniferous Phosphate of Lead.—This substance occurs at Iohangeorgenstadt in yellow hexagonal prisms, the terminal edges of which are replaced by single planes.

It presents crystalline faces after fusion by the blowpipe, as phosphate of lead does, and it exhales an abundance of arsenical fumes when fused on charcoal. It appears, therefore, to contain both arsenic and phosphoric acids, but I cannot find any analysis of it published.

I have taken this notice of it for the purpose of observing that the same species is found also at Beeralston in small yellow hexagonal prisms, and has been called arseniate of lead; from which, however, it may be readily distinguished by its crystalline character after fusion.

Carbonate of Magnesia and Iron.—On measuring the angles of different specimens of the substances which have been called bitter spar, or magnesian carbonate of lime, I have found one variety differing in its angle from all the others. This is the yellow variety from the Tyrol, which occurs in single crystals imbedded in talc or chlorite.

Its form is an obtuse rhomboid, measuring 107° 30′, the corresponding angle of the true bitter spar being 106° 15′.

On observing this difference in the angle, I dissolved a portion of the yellow crystals in dilute sulphuric acid, and obtained from

the solution crystals of sulphate of magnesia, tasting, however, very strongly of iron.

There was no residuum except a small quantity of the talc which penetrated the fragment I examined,* and the solution gave no trace of lime; the mineral appears, therefore, to be a carbonate of magnesia and iron.

Ten grains kept for some time at a red heat lost 4·82, and the colour became a snuff-brown.

Ten grains dissolved in dilute muriatic acid left a small insoluble residuum, apparently of the talc in which the mineral is imbedded. A few drops of nitric acid being added to peroxidate the iron, a precipitate was obtained by succinate of ammonia, which, when washed, and heated to redness, to destroy the succinic acid, weighed 1 gr.

From this experiment, the mineral might consist of 1 atom of carbonate of iron, and 9 atoms of carbonate of magnesia.

For if to the apparent loss by heating .... 4·820
we add the increase occasioned by the peroxidation of the iron, we shall have the true weight of the matter driven off.

1 gr. peroxide of iron, equivalent to ·815 protoxide, difference .... 0·185

5·005

0·815 protox. of iron requires of carbonic acid for saturation 0·500

0·500 carbonic acid	If this be carbonic acid .... 4·505
1·315 carb. iron	it would require of magnesia for its
8·605 carb. mag.	saturation .... 4·100
9·920	Giving carbonate of magnesia..... 8·605

If we consider 7·25 as the equivalent for carbonate of iron, and 5·25 as that of carbonate of magnesia, we should have

7·25 : 5·25 :: 1·315 : 0·95 nearly
And 0·95 : 8·605 :: 1 : 9 nearly.

But a more accurate analysis might possibly vary these proportions.

Latrobite.—It is to the Rev. C. I. Latrobe that I am indebted for specimens of the mineral to which I have given this designation. And mineralogy is also indebted to him for the researches he has himself made, and caused to be made by others, in remote districts seldom visited by Europeans.

The mineral in question came from Amitok Island near the coast of Labrador; it is accompanied by mica and carbonate of

* The true bitter spar leaves a pulpy residuum of sulphate of lime when dissolved in dilute sulphuric acid.

lime, and imbedded in a grayish-coloured substance which I suppose to be also new to mineralogy.

The colour of latrobite approaches to pink like some of the deep coloured varieties of lepidolite.

Its specific gravity is about 2·8.

It scratches glass, and is scratched by felspar.

It has cleavages in three directions, parallel to the lateral and terminal planes of a doubly oblique prism, P on M, 98° 30′; P on T, 91°; M on T, 93° 30′. (See the figure already given.) The plane parallel to P is very dull, and the measurement obtained from it not to be confidently relied on; those parallel to M and T afford good reflections, but one of these is brighter than the other.

I send herewith specimens of the arfwedsonite and latrobite, which you will, perhaps, take the trouble to analyze at your leisure; and I remain, yours truly,

H. J. Brooke.

Article XIII.

On the Discovery of Acids in Mineral Substances. By James Smithson, Esq. FRS.

(To the Editor of the *Annals of Philosophy*.)

Sir, *April* 12, 1823.

Acids, it is well known, have been repeatedly overlooked in mineral substances, and hence dubiousness still hovers over the constitution of many, although they have formed the subjects of analysis to some of the greatest modern chemists.

To be able to dissipate all doubts—to ascertain with certainty whether an acid does or does not exist, and, if one is present, its species, and this with such facility that the trial may be indefinitely renewed at pleasure, and made by all, so that none need believe but on the testimony of his own experiments, is the degree of analytical power which it would be desirable to possess.

So far as I have gone in these respects, I here impart.

As the carbonates of soda and of potash precipitate all the solutions of earths and metals in acids, so do they decompose all their salts by fusion with them. Fusion with carbonate of soda or potash affords there a general method of separating acids from all other matters.

Lead forms an insoluble compound with all the mineral acids except the nitric. It may consequently be immediately known whether a mineral does or does not contain an acid element by

the carbonate of soda or potash, with which it has been fused after saturation by acetous acid, forming or not forming a precipitate with a solution of lead.

If the production of a precipitate proves the presence of an acid, the determination of its species will present no great difficulty.

1. *Sulphuric Acid.*—If the alkali which has received it from the mineral is fused on charcoal, and then laid in a drop of water placed on silver, a spot of sulphuret of silver will be produced, as I have stated on a former occasion.* Bright copper will likewise serve for this purpose.

Fusion in the blue flame will often be sufficient to deoxidate the sulphur.

It is needless to observe that the alkali used in this trial must itself be perfectly free from sulphuric acid. When such is not possessed, its place may be supplied by Rochelle salt, or by cream of tartar.

2. *Muriatic Acid.*—I have likewise discovered a test of chlorine, and consequently of muriatic acid, of delicacy equal to the foregoing. If any matter containing chlorine or muriatic acid is laid on silver in a drop of solution of yellow sulphate of iron, or of common sulphate of copper, a spot of a black chloride of silver, whose colour is independent of light, and which has not been attended to by chemists, is produced. The chlorine in a tear, in saliva, even in milk, may be thus made evident. When the quantity of chlorine in a liquor is very small, a bit of sulphate of copper placed in it on the silver is preferable to a solution. To find chlorine in milk, I put some sulphate of copper to it, and placed a small piece of bright silver in the mixture.

3. *Phosphoric Acid.*—The alkali containing it, after saturation by acetous acid, gives a sulphur-yellow precipitate with nitrate of silver, which no other acid does. The precipitate obtained with lead crystallizes on the blowpipe. M. Berzelius's elegant method of detecting phosphoric acid is universally known.

4. *Boracic Acid.*—Its presence in carbonate of magnesia, and in some other of its compounds, is indicated by the green colour they give, during their fusion, to the flame of the lamp.

M. Gay-Lussac has observed that a solution of boracic acid in an acid changes the colour of turmeric paper to red, like an alkali.† Borax, to which sulphuric acid has been put, does so, and the same is of course the case with a bead of soda containing boracic acid.

The most certain test of boracic acid in a soda bead, &c., is to add sulphuric acid to it and then spirit of wine, whose flame is coloured green, if boracic acid is present.

* *Annals of Philosophy* for July, 1820.

† Annales de Chimie et de Physique, tome xvi. p. 75.

5. *Arsenical Acid.*—Alkali containing it produces a brick-red precipitate with nitrate of silver.*

6. *Chromic Acid.*—Chromate of soda and its solution are yellow, and so is the precipitate with lead. That with silver is red.

Chromate of soda or potash fused on a plate of clay leaves green oxide of chromium.

Chromate of lead fused on a plate of clay produces a very dark-green mass, which is probably chromate of lead; with an addition of lead, it forms a fine red, or orange glass.

Lead added to the green oxide left by chromate of soda on the clay plate, dissolves it, and forms an orange-coloured glass.

The green oxide of chromium sometimes acts the part of an acid. I have seen a combination of it with oxide of lead found in Siberia, in regular hexagonal prisms, having the six edges of the terminal face truncated (Haüy, pl. lxviii. fig. 63); melted with lead on the clay plate this would undoubtedly produce the orange glass; and fused with nitrate of potash it would form chromate of potash.

7. *Molybdic Acid.*—If molybdate of soda or potash, or, I apprehend, any other molybdate, is heated in a drop of sulphuric acid, the mixture becomes of a most beautiful blue colour, either immediately, or on cooling.

The solution of molybdate of soda in sulphuric acid affords with martial prussiate of potash, a precipitate of the same colour that copper does. Tincture of galls gives with this acid solution a green precipitate; but with an alkaline solution of molybdic acid galls produce a fine orange precipitate. If an alkali is put to the green precipitate, it becomes orange; and if an acid to the orange precipitate, it becomes green.

8. *Tungstic Acid.*—If tungstate of soda is heated with sulphuric acid, the granules of precipitated tungstic acid become blue, but not the solution; and the phenomena cannot be confounded with those presented by molybdate of soda. Martial prussiate of potash has no effect on this acid liquor.

Tincture of galls put to the solution of tungstate of soda in water does not affect it. On the addition of an acid to this mixture, a brown precipitate forms.

If tungstate of soda is heated to dryness with a drop of muriatic acid, a yellow mass is left. On extracting the saline matter by water, yellow acid of tungsten remains. It is readily soluble in carbonate of soda. If taken wet on the blade of a knife, it soon becomes blue. This is made very evident by wiping the blade of the knife with a bit of white paper. Possibly a small remainder of muriatic or sulphuric acid among it is required for this effect.

9. *Nitric Acid.*—Nitrate of ammonia produces no deflagration when filtering paper, wetted with a solution of it and dried, is

* *Annals of Philosophy*, N. S. vol. iv. p. 127.

burned; the salt volatilizing before ignition, most, or all, the other nitrates deflagrate.

If metallic copper is put into the solution of a nitrate, sulphuric acid added, and heat applied, the copper dissolves with effervescence.

10. *Carbonic Acid.*—It is to be discovered in the mineral itself. The application of heat is, in some cases, required to render the effervescence sensible. It has been sometimes overlooked in bodies from want of attention to this circumstance.

11. *Silica.*—A simple and sufficient test of it is the formation of a jelly, when its combination with soda is put into an acid.

It has evidently not been intended to enumerate all the means by which the presence of each acid in the soda bead could be perceived or established. Little has been said beyond what appeared required and sufficient.

Mention has been made above of small plates of clay.

They are formed by extending a white refractory clay by blows with the hammer, between the fold of a piece of paper, like gold between skins. The clay and paper, and then cut together with scissars into pieces about 4-10ths of an inch long, and $2\frac{1}{4}$-10ths of an inch wide, and hardened in the fire in a tobacco-pipe.

They are very useful additions to the blowpipe apparatus. They admit the use of a new test, oxide of lead. They show to great advantage the colours of matters melted with borax, &c. Quantities of matter too minute to be tried on the coal, or on the platina foil, or wire, may be examined on them alone, or with fluxes. Copper may be instantly found in gold or silver by fusing the slightest scrapings of them with a little lead, &c. &c.

Cut into very small, very acute triangles, clay affords a substitute for Saussure's sappare.

Article XIV.

Analyses of Books.

Narrative of a Journey to the Shores of the Polar Sea, in the Years 1819, 1820, 1821, *and* 1822. By John Franklin, Capt. RN. FRS. and Commander of the Expedition. *With an Appendix on various Subjects relating to Science and Natural History. Illustrated by numerous Plates and Maps. Published by Authority of the Right Honourable the Earl Bathurst.*

The late period of the month at which this most interesting work has been submitted to our attention, in conjunction with

other circumstances, compels us to postpone, for the present, the regular analysis of it which we purpose to give; and to content ourselves with extracting from the copious Appendix, the following observations on the Aurora Borealis, to which subject Capt. Franklin's attention was expressly directed in his Instructions.

Aurora Borealis.

"*General Remarks.*—So few observations of the Aurora Borealis in high northern latitudes have been recorded, that I trust a minute account of the various appearances it exhibits, will not be thought superfluous or uninteresting. The remarks of the late Lieut. Hood are copied verbatim from his journal. They speak sufficiently for themselves, to render any eulogium of mine unnecessary. To this excellent and lamented young officer, the merit is due of having been, I believe, the first who ascertained by his observations at Basquiau-Hill (combined with those of Dr. Richardson at Cumberland House), that the altitude of the Aurora upon these occasions was far inferior to that which had been assigned to it by any former observer. He also, by a skilful adaptation of a vernier to the graduated circle of a Kater's compass, enabled himself to read off small deviations of the needle, and was the first who satisfactorily proved, by his observations at Cumberland House, the important fact of the action of the Aurora upon the compass-needle. By his ingenious electrometer invented at Fort Enterprise, he seems also to have proved the Aurora to be an electrical phenomenon, or at least that it induces a certain unusual state of electricity in the atmosphere."

"The observations of Dr. Richardson, independent of their merit in other respects, point peculiarly to the Aurora being formed at no great elevation, and that it is dependent upon certain other atmospheric phenomena, such as the formation of one or other of the various modifications of cirro-stratus."

"With respect to my own observations, they were principally directed to the effects of the Aurora upon the magnetic needle, and the connexion of the amount, &c. of this effect, with the position and appearance of the Aurora. I have been anxious to confine myself to a mere detail of facts, without venturing upon any theory. My notes upon the appearances of the Aurora coincide with those of Dr. Richardson, in proving, that that phenomenon is frequently seated within the region of the clouds, and that it is dependent, in some degree, upon the cloudy state of the atmosphere."

"The manner in which the needle was affected by the Aurora will need some description. The motion communicated to it was neither sudden nor vibratory. Sometimes it was simultaneous with the formation of arches, prolongation of beams, or certain other changes of form, or of activity of the Aurora; but

generally the effect of these phenomena upon the needle was not visible immediately, but in about half an hour or an hour, the needle had attained its maximum of deviation. From this, its return to its former position was very gradual, seldom regaining it before the following morning, and frequently not until the afternoon, unless it was expedited by another arch of the Aurora operating in a direction different from the former one."

"The bearings of the terminations of the arches are to be taken with considerable allowance. They were estimated by the position of the Aurora, with respect to the sides of the house, the angles of which had been previously determined. The bearings given in the whole of my observations refer to the magnetic meridian, and are reckoned from the magnetic north, towards the east round the whole circle, which, it is conceived, will afford a means of more readily computing the horizontal extent of the arches."

"It is to be noticed, that the bearings given by Dr. Richardson and Lieut. Hood are true, and not magnetic."

"*On the Aurora Borealis, Cumberland House. Extracted from the Journal of Lieut. Robert Hood, RN.*—The most material information we had obtained at this period regarded the height of the Aurora from the earth. The following is the result of the observations that were made at the Basquiau Hill, and at the same time by Dr. Richardson at Cumberland House. The instruments used for the purpose were two small wooden quadrants, revolving on pivots, and furnished with plummets. Our chronometers were previously regulated, though great accuracy was not necessary in this particular, as the arches of the Aurora are sometimes stationary for many minutes. On the 2d of April, the altitude of a brilliant beam was 10° 0′ 0″, at 10hs 1m 0s, p.m. at Cumberland House. Fifty-five miles SSW it was not visible. As the trees at the latter station rose about 5° above the horizon, it may be estimated that the beam was not more than seven miles from the earth, and twenty-seven from Cumberland House. On the 6th of April, the Aurora was, for some hours, in the zenith at that place, forming a confused mass of flashes and beams; and in lat. 53° 22′ 48″ N, long. 103° 7′ 17″ W, it appeared in the form of an arch, stationary about 9° high, and bearing N by E. It was, therefore, seven miles from the earth. On the 7th of April, the Aurora was again in the zenith before 10, p.m. at Cumberland House, and in lat. 53° 36′ 40″ N, and long. 102° 31′ 41″; the altitude of the highest of two concentric arches at 9hs p.m. was 9°; at 9hs 30m, it was 11° 30′; and at 10hs 0m 0s, p.m. 15° 0′ 0″, its centre always bearing N by E. During this time, it was between six and seven miles from the earth. After 10hs, p.m. it covered the sky at Cumberland House, and passed the zenith at the other place."

"These observations are opposed to the general opinion of

meteorologists; they are nevertheless facts. We have sometimes seen an attenuated Aurora flashing across 100° of the sky in a single second; a quickness of motion inconsistent with the height of sixty or seventy miles, the least of which has hitherto been ascribed to it. This kind of Aurora is not brighter than the milky way, and resembles sheet-lightning in its motions."

"For the sake of perspicuity, I shall describe the several parts of the Aurora, which I term beams, flashes, and arches. The beams are little conical pencils of light, ranged in parallel lines, with their pointed extremities towards the earth, generally in the direction of the dipping needle. The flashes seem to be scattered beams approaching nearer to the earth, because they are similarly shaped, and infinitely larger. I have called them flashes, because their appearance is sudden, and seldom continues long. When the Aurora first becomes visible, it is formed like a rainbow, the light of which is faint, and the motion of the beams undistinguishable. It is then in the horizon. As it approaches the zenith, it resolves itself at intervals, into beams, which, by a quick undulating motion, project themselves into wreaths, afterwards fading away, and again brightening, without any visible expansion or concentration of matter. Numerous flashes attend in different parts of the sky. That this mass, from its short distance above the earth, would appear like an arch to a person situated at the horizon, may be demonstrated by the rules of perspective, supposing its parts to be nearly equidistant from the earth. An undeniable proof of it, however, is afforded by the observations of the 6th and 7th of April, when the Aurora which filled the sky at Cumberland House, from the northern horizon to the zenith, with wreaths and flashes, assumed the shape of arches at some distance to the southward."

"But the Aurora does not always make its first appearance as an arch. It sometimes rises from a confused mass of light in the east or west, and crosses the sky towards the opposite point, exhibiting wreaths of beams, or coronæ boreales in its way. An arch, also, which is pale and uniform at the horizon, passes the zenith without displaying any irregularity or additional brilliancy; and we have seen three arches together, very near the northern horizon, one of which exhibited beams and even colours, but the other two were faint and uniform."

"On the 7th of April, an arch was visible to the southward, exactly similar to that in the north, and it disappeared in fifteen minutes. It had probably passed the zenith before sunset. The motion of the whole body of Aurora is from the northward to the southward, at angles not more than 20° from the magnetic meridian. The centres of the arches were as often in the magnetic as in the true meridian."

"The colours do not seem to depend on the presence of any luminary, but to be generated by the motion of the beams, and then only when that motion is rapid, and the light brilliant.

The lower extremities quiver with a fiery red colour, and the upper with orange. We once saw violet in the former. The number of Auroræ visible in September was two; in October, three; in November, three; in December, five; in January, five; in February, seven; in March, sixteen; in April, fifteen; and in May, eleven. Calm and clear weather was the most favourable for observation; but it is discernible in cloudy weather, and through mists. We could not perceive that it affected the weather. The magnetic needle, in the open air, was disturbed by the Aurora, whenever it approached the zenith. Its motion was not vibratory, as observed by Mr. Dalton; and this was, perhaps, owing to the weight of the card attached to it. It moved slowly to the E or W of the magnetic meridian, and seldom recovered its original direction in less than eight or nine hours. The greatest extent of its aberration was 45′."

"A delicate electrometer, suspended at the height of fifty feet from the ground, was never perceptibly affected by the Aurora, nor could we distinguish its rustling noise, of which, however, such strong testimony has been given to us, that no doubt can remain of the fact. The conclusions to be drawn from the above will be found in the observations for the winter of 1820."

(To be continued.)

Article XV.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

*** We endeavoured, last month, to give a full report of the important paper communicated by the President to the Royal Society, on the 5th of March; but writing only from memory, we have made two errors, one with respect to the rotation of the mercury not being stopped, but produced, by the approximation of the magnet; the other in the historical paragraph in the conclusion, which, as we have stated it, is unjust to Mr. Faraday, and does not at all convey the sense of the author. We wish, therefore, to refer our readers forward to the original paper, when it shall be published, for the correction of these mistakes.—*Edit.*

March 20.—At this meeting the reading of the following paper, which had been commenced on the 13th, was resumed and concluded.

Of the Motions of the Eye, in Illustration of the Uses of the Muscles of the Orbit. By Charles Bell, Esq. (Communicated by the President.)

In this paper the author enters upon an examination of the motions of the eye, and the classification of the muscles according to their offices. This is done for the purpose of explaining the uses of the six nerves which enter into the orbit, and in pursuance of his former papers on the nervous system.

His object in this paper is to show, in the first place, that there are motions performed by the eye not hitherto noticed. Every time the eyelids descend to cover the transparent part of the eye, the eyeball ascends, or suffers a revolving motion. If this were not the case, the surface of the eye would not be moistened, nor freed from offensive particles. He proves, in the next place, that when we fall asleep, the eyeball is turned up, and the cornea lodges secure and moistened by the tears, under cover of the upper eyelid. He shows that these motions are rapid and insensible, and that they are provided for the safeguard of the eye. The other motions are voluntary, and for the purpose of directing the eye to objects. He then proceeds to the examination of the muscles of the eyeball, distinguishing them, as usual, into the straight and oblique muscles. It has been supposed, hitherto, that both these classes of muscles were voluntary; some describing the oblique muscles as coadjutors of the recti, and others as opponents to the recti; but Mr. Bell maintains that the obliqui are provided for the insensible motions of the eyeball, and the recti for those motions which are directed by the will, and of which we are conscious.

He proceeds to show, that the consciousness of the action of the recti muscles, gives us the conception of the place or relation of objects. He then proves by observation and experiment, that the actions of the straight muscles are inseparably connected with the activity of the retina; that is, with the enjoyment of the sense of vision: but that the moment the vision is unexercised, the eyeball is given up to the operation of the oblique muscles, and the pupil is consequently drawn up under the eyelid. Hence, the eyes are elevated in sleep, in faintness, and on the approach of death; and that distortion which we compassionate as the expression of agony, is the consequence merely of approaching insensibility.

Having examined the different motions of the eye and eyelids, and the muscles which are appropriated to them, the author promises, in the second part of the paper, to explain on this foundation, the distinction in the uses of the nerves of the orbit.

The Society then adjourned, in consequence of the approaching fast and festival, to meet again on

April 10, when the following paper was read: An Account of an Apparatus on a peculiar Construction, for the Exhibition of Electromagnetic Experiments. By W. H. Pepys, Esq. FRS.

This apparatus, constructed at the London Institution, under the direction of the author, consists of two plates, the one of copper, and the other of zinc, each two feet wide, and 50 feet

long, giving a total surface of 200 square feet. These plates are wrapped or coiled round a common centre, and are prevented from contact with each other by the interposition of three cords of hair line, and also of notched slips of wood placed at intervals. Two conductors of copper wire, nearly three-fourths of an inch in diameter, are attached, one to the zinc, and the other to the copper plate. In order that so large a mass may be readily employed for experiment, the apparatus is suspended by means of pulleys and a counterpoise, and so let down into a tub of acid, or, when not in use, into one of water. It requires 55 gallons of fluid.

This instrument exhibits very powerful magnetic effects: when the contact was made, a change in the direction of compass needles was produced, at the distance of five feet; steel bars enclosed in cylinders of glass, with a spiral of wire round them, were rendered magnetic, and several were suspended together; when the contact was broken, the bars fell, but one of them was immediately taken up again on restoring the contact, though it weighed above 270 grains. The electric intensity of the apparatus is very slight; it has not any decomposing action, and will not make a spark with charcoal, nor will it deflagrate the metals.

A paper was also read, On the Condensation of several Gases into Liquids. By M. Faraday, Chemical Assistant in the Royal Institution. (Communicated by the President.)

In this paper, Mr. Faraday described the results obtained by the application of the mode of condensation by which he had succeeded in liquefying chlorine, and Sir H. Davy muriatic acid gas, to several other aëriform bodies.

A portion of sulphuric acid being heated with mercury at one end of a sealed glass tube, while the other was kept cool by moistened bibulous paper, the *sulphurous acid gas*, which was evolved, condensed into a liquid in the cool end: the same result was obtained by forcing the dry gas into an exhausted tube with a condensing syringe, until its pressure became equal to three or four atmospheres. When the sealed tube was broken, the liquid expanded into pure sulphurous acid gas. The refractive power of *liquid sulphurous acid* is nearly that of water; the pressure exerted by its vapour in the tube was determined, by means of a mercurial guage, to be equal to two atmospheres. *Liquid sulphuretted hydrogen* was produced in the following manner: The small and closed leg of a bent tube was filled with muriatic acid; a piece of platinum foil, crumpled up, was next introduced; and then some fragments of sulphuret of iron; the platinum foil being interposed in order to prevent the two substances from contact until the tube was sealed, which operation would otherwise have been rendered ineffectual by the pressure of the evolved gas. When this had been done, the acid was made to

flow upon the sulphuret, and, in space of 24 hours, protomuriate of iron, and *liquid sulphuretted hydrogen*, were formed. When the tube was broken, under water, a portion of the gas which arose was collected, and found to be pure sulphuretted hydrogen, with which, also, the water was found to be impregnated. Sulphuric ether, when compared with this liquid, appeared adhesive and oily; the pressure which its vapour exerts, in the tube, is equal to 13 atmospheres, at 32° F. *Liquid carbonic acid* was produced in a similar manner, by means of sulphuric acid and carbonate of ammonia; but the strongest tubes were required for its formation, and tubes which had contained it for several weeks, often exploded with great violence upon a slight change of temperature. It was necessary to use a glass mask, goglers, &c. in the whole of these experiments; and some of them were attended with much risk to the author. The refractive power of liquid carbonic acid is much less than that of water; the pressure exerted by its vapour is equal to 40 atmospheres at about 45°. *Euchlorine* was liquefied, by its evolution, in a sealed tube, from chlorate of potash and sulphuric acid; in this state, it is of a deep-yellow colour, and quite transparent.

Some nitrate of ammonia, previously rendered as dry as possible by being heated to partial decomposition, was heated in a closed tube; and the results were, *liquid nitrous oxide* and water: the two fluids did not mix, or but in a slight degree. The refractive power of liquid nitrous oxide is lower than that of any of these fluids, and lower, indeed, than that of any other known liquid. Its vapour exerts a pressure equal to 48 atmospheres at 50°. *Liquid cyanogen* was formed by heating cyanuret of mercury; when the tube was broken, it became pure cyanogen gas.

The liquefaction of *ammoniacal gas* was effected by heating a portion of chloride of silver which had absorbed a large quantity of it, according to a property of this and of other chlorides formerly ascertained by the author. In this experiment, a curious combination of effects took place; as the tube cooled, the chloride began to re-absorb the ammonia, by the solidification of which, heat was liberated; while, at the distance only of a few inches, at the opposite end of the tube, cold was produced by the consequent evaporation of the liquid. At 60°, the whole of the ammonia became re-absorbed. The refractive power of *liquid ammonia* exceeds that of any other liquid described in this paper, and is even greater than that of water. *Liquid muriatic acid*, when the substances from which it is prepared are pure, is colourless, as Sir H. Davy had anticipated: its refractive power is nearly that of liquid carbonic acid.

All these liquids, with the exception of chlorine and euchlorine, are colourless; all are perfectly transparent, and highly fluid, and remain so at all temperatures to which they have been subjected; none of them exhibiting the least tendency to adhe-

tiveness at 0°. Experiments had been made, with a view to the liquefaction of oxygen, hydrogen, phosphuretted hydrogen, fluosilicic, and fluo-boracic gases, but these substances had hitherto resisted all powers of condensation that the author had been able to apply to them. With respect to the latter gas, this seemed to arise from its great affinity for sulphuric acid, as discovered by Dr. J. Davy, which is so great, that it even carries up that acid with it, in the form of vapour. Mr. Faraday intimated, however, that he should proceed with these experiments.

GEOLOGICAL SOCIETY.

April 4.—Two notices were read on a Recent Ligneous Petrifaction. By the Rev. J. J. Conybeare, MGS.

A notice was also read, respecting a Mass of Quartzose Ferruginous Sandstone, occurring in the Limestone near Bristol. By George Cumberland, Esq. Hon. MGS.

April 18.—A letter was read, containing "A Description of Two New Species of Encrinus found in the Mountain Limestone near Bristol." By the same.

A letter was also read, "On the Geology of Pulo Nias, an Island on the Western Side of Sumatra." By Dr. Jack. (Communicated by H. T. Colebrooke, Esq. MGS.)

A paper was read, "On the Geology and Geography of Sumatra, and some of the adjacent Islands." By Dr. Jack. (Communicated by H. T. Colebrooke, Esq. MGS.)

ASTRONOMICAL SOCIETY.

April 11.—A letter was read from M. Pastorff to the late President, on a Photosphere observed at Buckholts, in Germany, round Venus, Jupiter, and Saturn.

At the same meeting was read, an Extract of a Letter from M. Littrow, Director of the Imperial Observatory at Vienna, to the Foreign Secretary, relative to the Cause of certain Discrepancies in Astronomical Observations; on the Construction of Instruments, and on Correction for Refraction.

ARTICLE XVI.

SCIENTIFIC INTELLIGENCE, AND NOTICES OF SUBJECTS CONNECTED WITH SCIENCE.

I. *Alkanet as a Test.*

Dr. Robert Hare, of Philadelphia, finds that the colour of alkanet may be used instead of litmus, producing the same phenomena, but in a reversed order; for the alkanet infusion is made blue by an alkali, and restored by an acid, instead of being, as in the case of litmus, reddened by an acid, and restored by an alkali. Thus as the one is indi-

rectly a test for alkalies, so is the other for acids. When infusion of alkanet is made blue for the latter purpose, the smallest quantity of alkali should be used that is adequate to the effect, in order to preserve the delicacy of the test.—(American Journal.)

II. *Analysis of the Mineral Waters of Carlsbad.* By M. Berzelius.

These waters deposit a calcareous tufa, of a striated crystalline texture, which possesses all the characters of arragonite. Prof. Stromeyer's discovery, that arragonite always contains strontian, induced M. Berzelius to search for that earth in this tufa, and in the waters by which it is deposited; and he has succeeded in finding a small quantity of it in both. The following is the general result of his analysis of the waters of the principal spring, called the *Sprudel*.

In 1000 parts of the water, there are of

Sulphate of soda	2·58714
Carbonate of ditto	1·25200
Muriate of ditto	1·04893
Carbonate of lime	0·31219
Fluate of ditto	0·00331
Phosphate of ditto	0·00019
Carbonate of strontian	0·00097
Carbonate of magnesia	0·18221
Phosphate of alumina	0·00034
Carbonate of iron	0·00424
Silica	0·07504
	5·46656

With traces of carbonate of manganese.—(Ann. de Chim. et de Phys. xxi. 246.)

III. *Fothergillian Prize Medal to be given by the Medical Society of London, Bolt-court, Fleet-street.*

In conformity with the will of the late Dr. Anthony Fothergill, the Society resolve to give annually to the author of the best dissertation on a subject proposed by them, a gold medal, value 20 guineas, called the "Fothergillian medal," for which the learned of all countries are invited as candidates.

1. Each dissertation offered for this prize must be delivered to the Registrar in the Latin or English language, on or before the 31st day of December.

2. With it must be delivered a sealed packet, with some motto or device on the outside; and within, the author's name and designation; and the same motto or device must be put on the dissertation, that the Society may know how to address the successful candidate.

3. No paper in the hand-writing of the author, or with his name affixed can be received; and if the author of any paper shall discover himself to the Committee of Papers, or to any member thereof, such paper will be excluded from all competition for the medal.

4. The prize essay will be read before the Society, at the meeting preceding the Anniversary Meeting of the Society, in March, 1824.

5. The prize medal will be presented to the successful candidate, or his substitute, at the Anniversary Meeting of the Society.

6. All the dissertations, the successful one excepted, will, if desired, be returned with the sealed packets unopened.

One dissertation only on the subject "Dropsy," proposed by the Society for the Fothergillian medal, to have been adjudged in March, 1823, having been presented, the Society thinking it probable that from the recent establishment of the prize, it had not been sufficiently made known to the medical faculty, have deferred the adjudication of the prize for the best dissertation on the subject of "Dropsy," to another year.

The subject of the Essay for the gold prize of the ensuing year is "Diseases of the Spine."

Article XVII.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

Mr. Goldsworthy Gurney is about to publish a Series of Lectures on the Elements of Chemical Science, lately delivered at the Surrey Institution.

Mr. Oliver has in the press, Popular Observations on Muscular Contraction, with a Mode of Treatment of Diseases of Limbs associated therewith.

In the press, a Translation of De Humboldt's Geognostical Essay on the Superposition of Rocks.

Dr. Antommarchi, formerly Professor of Anatomy in the University of Pisa, and Surgeon to the late Ex-Emperor at St. Helena, is publishing an Anatomical Work, to be comprised in 80 Plates, representing the whole Structure of the Human Body, except the Integuments, in Figures of the natural Size. An explanatory and descriptive Sketch will be added to every Plate in which the multiplicity of figures might otherwise create confusion. The Work is edited by M. le Comte de Lasteyrie.

Mrs. Holderness is employed on a Work on New Russia, being some Account of the Colonization of that Country, and of the Manners and Customs of the Colonists.

JUST PUBLISHED.

A Journal of a Voyage to the Northern Whale Fishery, including Researches and Discoveries on the Eastern Coast of West Greenland, made in the Summer of 1822, in the Ship Baffin, of Liverpool. By W. Scoresby, Jun. FRSE. Commander. With 8 Plates, 8vo. 16s.

Dendrologia Britannica, or Trees and Shrubs that will live in the open Air of Britain throughout the Year. By P. W. Watson. Royal 8vo. Parts I. to IV. 4*s*. 6*d*. each. Each Number contains 8 coloured Engravings.

Hortus Cantabrigiensis, or an Accented Catalogue of Plants, Indigenous and Exotic, cultivated in the Cambridge Botanic Garden. By the late J. Donn, FLS. and FHS. Tenth Edition, with numerous Corrections and Additions, by John Lindley, FLS. &c. 8vo. 10*s*. 6*d*.

Elements of Experimental Chemistry. By William Henry, MD. FRS. &c. The Ninth Edition, greatly enlarged and recomposed throughout. Illustrated with 10 Plates by Lowry, and numerous Wood-cuts. In 2 Vols. 8vo. 1*l.* 14*s.*

Narrative of a Journey from the Shores of Hudson's Bay to the Mouth of the Copper Mine River, and thence along the Coast of the Polar Sea, &c. By Capt. John Franklin, RN. Commander of the Expedition. With an Appendix containing Subjects of Natural History, &c. by J. Richardson, MD. Surgeon to the Expedition, and others. Illustrated by 4 Maps, 8 Plates of Natural History, and 24 Engravings by Finden, from Drawings by Lieuts. Back and Hood: 4to. 4*l.* 4*s.*

Among the new productions at the present Leipzig Fair, is the first Volume of MM. Martin and Spix's Travels in Brazil, during the Years 1817, 1818, 1819, and 1820; with an Atlas, in imperial Folio, of 15 Lithographic Plates of Portraits, Views, Geological and Botanical Charts, &c. This Volume contains their Travels though Rio Janeiro, St. Paul, Minas Geraes, Goyaz, Bahia, &c.

Also:—Animalia Nova quæ in Itinere jussu et auspiciis Max. Jos. Bav. Regis per Brazilium suscepto observavit, et depingi curavit Dr. Joannes de Spix. 39 Plates.

Plantæ Novæ quæ in Itinere jussu et auspiciis Max. Jos. Bav. Regis suscepto observavit, et depingi curavit, Dr. Carolus de Martin. 100 Plates.

The Naturalist's Repository, or Monthly Miscellany of Exotic Natural History, consisting of elegantly coloured Plates, with appropriate scientific and general Descriptions of the most curious, scarce, and beautiful Productions of Nature that have been recently discovered in various Parts of the World. By E. Donovan, FLS. &c.

Article XVIII.

NEW PATENTS.

J. Taylor, of Raven-row, Mile End, Middlesex, master mariner, for a new method of constructing the bottoms of merchant-ships, and placing the pumps so as to prevent damage to the cargoes by the bilge-water.—Jan. 16.

J. Smith, of Old Broad-street, merchant, for certain improvements on a machine for washing, cleansing, and whitening cotton, linen, silk, and woollen garments, or piece goods.—Jan. 20.

W. Glossage, of Leamington Priors, Warwickshire, chemist and druggist, for a portable alarum, to be attached to, and detached from, clocks and watches, and which may be regulated to take effect at any given period of time.—Feb. 11.

N. Partridge, of Bowbridge, near Stroud, Gloucestershire, dyer, for improvements in the setting or fixing of steam-boilers or other coppers, by which a considerable saving of fuel will be effected, and the smoke more effectually consumed.—Feb. 14.

T. Fuller, of Bath, Somersetshire, coach-builder, for an improvement in the construction of shafts, and the mode of attaching them to two-wheeled carriages.—Feb. 18.

Article XIX.

METEOROLOGICAL TABLE.

1823.	Wind.	Barometer. Max.	Min.	Thermometer. Max.	Min.	Evap.	Rain.	Daniell's hyg. at noon.
3d Mon.								
March 1	N W	30·12	30·03	45	31	—		
2	W	30·11	29·83	48	30	—	04	
3	W	29·83	29·45	51	38	—	04	
4	N W	29·55	29·44	48	37	—		
5	N W	29·88	29·55	45	33	—		
6	N W	29·88	29·57	40	24	—		
7	S E	29·57	29·19	39	31	—	—	
8	N W	29·27	29·19	43	30	—		
9	N	29·88	29·27	44	26	—		
10	S E	29·84	29·77	44	31	—	26	
11	N W	30·19	29·84	48	32	—		
12	N W	30·35	30·19	48	30	—		
13	S W	30·35	30·33	52	32	—		
14	S W	30·50	30·33	52	38	·95	06	
15	N	30·55	30·50	50	30	—		
16	N	30·55	30·25	48	32	—	06	
17	N W	30·25	29·97	52	38	—	—	
18	N W	29·97	29·82	50	30	—	16	
19	N W	29·93	29·89	40	28	—	—	
20	S W	29·89	29·49	50	36	—	40	
21	S W	29·49	29·20	52	40	—	07	
22	S W	29·69	29·20	55	40	—	01	
23	N W	30·28	29·69	48	35	—	—	
24	E	30·39	30·28	55	33	—		
25	E	30·28	30·22	46	35	—		
26	N E	30·22	30·15	44	39	—		
27	N	30·15	30·14	44	32	—		
28	E	30·17	30·14	52	38	—		
29	E	30·14	30·12	51	39	—		
30	E	30·22	30·12	63	38	—	07	
31	N W	30·22	30·16	58	47	·80		
		30·55	29·19	63	24	1·75	1·17	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Third Month.—1. Fine. 2. Cloudy. 3. Drizzling rain: a furious gale of wind from the NW all night. 4. The wind continued to blow with great violence all day. 5. Fine. 6. Cloudy: bleak. 7. Snowy. 8. Cloudy. 9. Fine. 10. Rain. 11, 12. Fine. 13—15. Cloudy. 16. Fine. 17. Cloudy. 18. Drizzly. 19. Snowy morning: very cold wind NE in the night. 20. Snow in the morning: afternoon rainy: a lunar halo in the evening. 21. Drizzly. 22. Overcast. 23—26. Cloudy. 27. Cloudy: night foggy. 28. Cloudy and fine. 29. Cloudy. 30, 31. Fine.

RESULTS.

Winds: N, 4; NE, 1; E, 5; SE, 2; SW, 5; W, 2; NW, 12.

Barometer: Mean height

For the month.. 29·952 inches.

For the lunar period, ending the 4th.................. 29·676

For 15 days, ending the 12th (moon south).......... 29·678

For 13 days, ending the 25th (moon north)........... 30·049

Thermometer: Mean height

For the month.. 41·258°

For the lunar period.. 38·933

For 29 days, the sun in Pisces............................ 39·423

Evaporation.. 1·75 in.

Rain.. 1·17

Laboratory, Stratford, Fourth Month, 22, 1823. R. HOWARD.

ANNALS

OF

PHILOSOPHY.

JUNE, 1823.

Article I.

A new and easy Method of ascertaining the Degree of Temperature at which Water is at its Maximum Density. By Mr. James Crichton.

(To the Editor of the *Annals of Philosophy*.)

SIR, *Glasgow, May* 2, 1823.

Having lately been much engaged in determining the specific gravities of certain fluids, by means of adjusted balls of glass, and being satisfied that for simplicity and accuracy, no method whatever is nearly so good; I was led to think, that another important point could thereby with greater certainty be ascertained, than by any mode yet adopted. This is to determine the temperature at which water attains its maximum density.

Of all who have hitherto attempted to decide this question, whether British or foreign philosophers, no one seems to speak with the precision which might be desirable, of the degree at which the phenomenon takes place. The French say it is between 4 and 5 of Celsius, thus admitting an uncertainty of about 2° of Fahrenheit; some in our own country think it is at 39, while others place it at 40.

Any person who is aware of the many sources of error, and of the vague nature of the requisite compensations, will not wonder at this indecision; the difficulty alone, of maintaining an uniform temperature, throughout a large or deep body of water is very considerable; hence the bulkiness of the solid used by

the French for this purpose, having been a cylinder nine inches in diameter, and of the same height, must have rendered it a matter of uncommon difficulty in the quantity of water necessary. Whether this uniformity existed, at the moment of its greatest apparent gravity, may admit of some doubt, however carefully and constantly the thermometer may have been observed; besides, air-bubbles, which it would be almost impossible to see or remove, might have considerably increased the buoyancy of the suspended solid. To estimate the compensations for expansion, in the above-mentioned method, is perplexing, and for the mode by the weighing bottle is still more so; but to ascertain the quantity of hygrometric humidity, which profusely and rapidly fixes on the exterior surface of a bottle, at so low a temperature as 40, is perhaps from several causes impracticable. A hope of being able to assist in obviating these embarrassments, induces me to present a new method of determining this point.

Having frequently observed that a very small alteration of temperature in a fluid, destroyed the precise poise of a solid in that fluid, and that an extremely minute increase or diminution of gravity in the solid, has a similar effect; it was easy to perceive, that if water is of a certain gravity just above freezing, and that if it become heavier, with an increase of temperature, before it reach, say for example, 50, then it is manifest, that at *some* included degree, water must of necessity poise, or sustain, a ball or solid of greater specific gravity, than it will do at any other point in the supposed interval.

My first attempt to ascertain this point, evinced, that a ball which was just poised, at about 33, had the same property near 51; this gave 42 for the point of greatest density, taking the half of the intervening degrees as additive to 33, or the reverse from 51, since all authorities seem to agree, that the expansion is the same for equal intervals of temperature, on both sides of the maximum.

It may be supposed, that to adapt a ball of the greatest possible specific gravity which water can sustain at *its* greatest gravity, would be the next endeavour; it was, but so infinitely little is the variation of the gravity of water, for about a half degree on either side of the maximum point, that although I have, more than once, diminished the gravity of balls which were too heavy, by a quantity so minute, as not to amount to the 6000th part of a grain, or just as little as I could by any means grind off, still, on trial at the proper range of temperatures, it was found that the mark had always been overshot. This then was relinquished as a hopeless task.

As it had not however escaped notice in the course of these experiments, that the further the temperature of water was removed from that of the greatest gravity, the ball rose, or fell, with celerity just commensurate to the number of degrees which

the existing temperature was above, or below, that of the desiderated degree: this, therefore, affords some idea of the approach to, or retrocession from, the temperature in question; but there is a better, and perhaps conclusive proof of its place in the scale, which I shall now describe.

I took a glass jar, 2 inches in diameter, and $3\frac{1}{4}$ in depth; into this was put distilled water to the depth of $2\frac{1}{2}$ inches, and cooled down to near the freezing point, but carefully prevented from congealing, as the disengagement of air-bubbles from the ice, when fluidity took place, would have frustrated the experiment; into this was put a ball, previously well wiped with a silken* cloth, and immediately, by means of a clean hook of glass, lifted, but not rapidly, twice or thrice out of the water; this cleared it of any air-bubbles, which though imperceptible, might have been adhering to its surface. The ball now fell to the bottom of the jar, which as usual was convex, but had a small flat surface on the summit, to which the ball was led, and there it rested. In the water there were suspended two very accurate and sensible thermometers, the bulbs being at the middle of the water as to depth, and just so far removed from its diametrical centre, as not to be in the path of the ball when it rose.

In these circumstances, the lower end of the ball was carefully watched with a large reading glass, and at the moment of its quitting the bottom of the jar, the thermometers were examined, and the degree noted; when the ball had risen about one-fourth of an inch a small rod was cautiously let down, and without agitating the water, gently made to touch the ball; it of course descended, but instantly rose; this is a very delicate part of the experiment, and if overdone loses its effect. It was frequently repeated, and the ball always reascended with accelerated velocity.

The thermometers indicating an increasing temperature, the ball finally became stationary at the surface of the water; from time to time it was slightly touched as before, but in proportion as the temperature rose beyond a certain point, the tendency of the ball to ascend, after these strokes, obviously diminished, judging by the velocity with which it did so; its upper extremity, when examined with the magnifier, plainly seemed to press as it were more and more feebly on the surface of the water, till at last, a fine thread of separation became visible; the degree by the thermometers was again marked, and as they continued slowly to rise, the ball gradually fell to the bottom of the jar.

From many similar experiments I have concluded that 42 is extremely near the true point of the greatest density of water; my most satisfactory trials never gave 3-10ths of a degree less

* In an experiment of such delicacy, this must be attended to, as linen never fails to leave fibres on whatever is wiped with it; these will detain air enough to render the efforts of the experimenter in this case abortive.

nor more, but at present, I am rather inclined to place it a very little above 42; a trial I made in very favourable circumstances a few days ago, gave for the first appearance of the rising of a ball 37·5, and for that of its sinking 46·3, these make the point in question 41·9; the local temperature was 46·8, but the barometer having been at only 29·4, the above 41·9 may be held perhaps too low. These experiments were made with balls adapted to all the intervals from 33—51 to 39—45, yielding however great uniformity of results.

As I cannot anticipate what objections, or if any, can be made to this method of ascertaining a curious and not unimportant point, I shall allude to one only; that is error from expansion of the ball, and consequent increase of its volume; but as the whole range required does not exceed 4° or 5°, on either side of a starting point, and though it were granted that the expansion of glass is the same for 4° about temperature 42, as it is for 180°, that is from freezing to boiling of water, as determined by M. de Luc and others, the expansion for these 4° must be so extremely little, as not by any means to affect the decision in any considerable part of a degree.

But were the expansion of glass in the above range even ten times what it is, still it must in effect be cancelled, for taking 42 as the point where this expansion in the present case must be assumed as incipient, and granting that at say 33, a ball just held in poise has become less, that is *heavier* specifically, some degree *above* 33, for example 34, where water is denser, must really be what the ball virtually indicates; again, if at 51 the same ball poises, then by a parity of reasoning the ball is now said to be increased in volume beyond what it was at 42, or it is too *light*, therefore it must indicate too high a degree, or it *really* shows that the ball, supposing it inexpansible, would have stood at a *lower* degree or denser medium, which call for instance 50; so that by the one extreme thus correcting the other, the conclusion to be drawn is the same as in the case of altogether neglecting the expansion.

The low temperature of the atmosphere when these experiments were made, gave confidence that no current upward or downward moved the water; besides, a few very minute particles of dust, just visible in different parts of it, remained entirely motionless during the whole operation.

My first trials on this subject were made with spherical balls, half an inch in diameter, having a depending stalk of about an equal length; but to obviate the possibility of error from dissimilarity of the extremities, I latterly used solids resembling in shape a buoy or parabolic spindle, sharp at the ends, of about an inch in length and 4-10ths in diameter. This shape gave another apparent advantage, that is of meeting less resistance than a sphere when moving in a fluid, and in order to ensure perpendicularity of the axis, before such a ball was hermetically sealed, a

small globule of mercury was introduced, which perfectly answers that purpose.

As the momentum of an ascending ball is very apt to cause its upper extremity to rise above the water, and however free of any thing unctuous, it will there remain too long, a slight tap or blow by a small hammer, on the under side of the table, will obviate this incident.

In cooling water for such experiments, it ought to be kept as still as possible; agitation to procure uniformity of temperature has a bad effect by charging it with air; bubbles may settle on the ball during the experiment, and must be closely watched for, as their effect may be apprehended, if detected occasionally rising through the water. Knowing the degrees at which a ball might be expected to rise or fall, I have frequently lifted it to the surface of the water a short time before, in order to free it of any thing which though imperceptible might have affected its gravity. The thermometers were sometimes placed one at the top, and the other at the bottom of the vessel, in order to ascertain beyond doubt the temperatures at the initial points, or the extremes of the above-mentioned intervals.

When it was considered how uncertain the indications might have been, had I succeeded in adjusting a ball to seeming equilibrium at the maximum gravity, owing to the minute variations near that point, there was little cause for regretting my failure, especially when the method by varied extents of intervals seems so satisfactory; still, since writing the above, another effort was made, when the following appearances took place.

Water in the jar being near 42, and the ball as seen by the naked eye in apparent equilibrio, it was observed with the reading glass as seen over a slight scratch on the side of the jar; it was then very slowly descending; having two or three times breathed on the part of the jar nearest the ball, the consequent dimness was removed by a camel hair brush, but before this could be done and the eye-glass applied, the ball had decidedly begun to ascend, which it continued to do for a few seconds, and after a momentary pause again began to fall. This was repeated several times, the thermometer meanwhile ranging from 42 to 42·6; from this and other circumstances, I with due deference incline to think, that 42·3 is very near the true point in the scale of temperature, where the maximum density of water takes place. In this last trial it may not be improper to mention, that the increment of weight producing the approximating effect, was a mere speck of leaf gold, attached to the side of the ball by means of spirit-varnish, and fixed by applying a moderate heat.

Having thus given an explicit account of these experiments, apology on my part for having too minutely done so, will be deemed quite unnecessary by any one who repeats them. I shall only add, that the thermometers having been made pur-

posely for the experiment, I have perfect reliance on their indications. The smallness of the apparatus and its extreme simplicity, render the determination of the point wherever it is to be placed, a very plain matter. This I submit to those who are capable of availing themselves of the means it affords, and who are qualified for appreciating its powers.

James Crichton.

Article II.

On a Salt composed of Sulphuric Acid, Peroxide of Iron, and Ammonia. By Dr. Forchhammer.

(To the Editor of the *Annals of Philosophy.*)

Dear Sir, *Copenhagen, April* 8, 1823.

Having prepared a solution of gold by means of nitric acid and muriate of ammonia, and precipitated the gold by protosulphate of iron, in order to determine whether any further portion of gold might be obtained by evaporation, the solution was concentrated to the consistence of a syrup, and suffered to remain for a month, when beautiful octohedral crystals of a wine yellow colour were formed on the sides of the vessel. It first occurred to me that this salt might be a peculiar compound of sulphuric acid and peroxide of iron; but I soon discovered that it also contained ammonia, and that it was an alum in which peroxide of iron supplied the place of alumina.

This salt is soluble in about three times its weight of water at 60°, and, by repeated crystallization, it may be obtained perfectly colourless; the regular octohedron is the most usual form of this salt, and although the cubo-octohedron sometimes occurs, I never obtained any perfect cubes.

Fifty parts of this salt were dissolved in water, and precipitated by nitrate of barytes, 50·33 of sulphate of barytes were obtained, containing 17·298 of sulphuric acid = 34·596 per cent.*

One hundred parts of the salt were dissolved in water, and decomposed by ammonia, the precipitate was digested during 24 hours in a solution of soda, and this, upon the addition of muriate of ammonia, deposited slight traces of alumina, which increased by ebullition, and weighed, when dry, 0·26 part. In another experiment, from 60 parts of the salt, 0·19 of alumina was obtained. The oxide of iron after being redissolved in muriatic

* In this and the following calculations, the proportions are given from Berzelius's tables (Stockholm, 1818). If the more simple numbers of Dr. Thomson are adopted, the result differs very little from that deduced from Berzelius's numbers.

acid and precipitated by ammonia weighed in the first experiment 16·37. From 50 parts of the salt in two subsequent experiments, I obtained 8·32 and 8·2, the mean of which is 8·233 = 16·47 per cent. Fifty parts of the salt were exposed for three days to a temperature near that of boiling water; when weighed, they had lost 21·74 = 43·48 per cent.; the remaining powder was readily dissolved in water, excepting a very small quantity of a brownish-red substance.

I found great difficulty in ascertaining the exact quantity of ammonia contained in this salt. I dissolved 100 parts in water, added caustic potash to the solution, and subjected it to distillation, so as to pass the vapour into a solution of nitrate of lead; although the subnitrate thus precipitated by ammonia is nearly insoluble in a solution of neutral nitrate of lead; it is, however, soluble in water, and when I washed the filter on which it was collected, it almost entirely disappeared. I attempted to expose these solutions of the subnitrate to the action of carbonic acid, which decomposes the subnitrate into carbonate and neutral nitrate, and then the quantity of carbonate of lead would be proportional to the quantity of ammonia passed through a neutral solution of the nitrate; this method did not, however, succeed much better, nor was nitrate of mercury employed with much greater advantage. At length on comparing the numbers for sulphuric acid and oxide of iron, I found that if I considered the persulphate to be composed, according to the proportions indicated by Berzelius as constituting what he terms sulphas ferricum, one-fourth of the sulphuric acid remained uncombined with oxide, and, I conceive, this quantity to be combined with ammonia.

One hundred and fifty parts of the salt were dissolved in water in a flask, and mixed with potash sufficient to decompose the whole; a glass tube was adapted to the flask, and immersed into a solution of 50 parts of the salt in question; the mixture in the flask was boiled for half an hour, and every precaution was taken to prevent the escape of any ammonia. At the close of the experiment, the solution through which the ammonia had passed was colourless; it slightly restored the blue colour of reddened litmus paper, but this effect did not take place unless the paper remained for some time in the solution; the precipitate had a yellowish colour indicating an admixture of subpersulphate of iron with the peroxide; the solution and precipitate were heated in a close vessel for 24 hours to a temperature of about 100°; the yellow colour of the precipitate had now disappeared, and it seemed to be pure peroxide of iron; the alkali of the solution was also so perfectly expelled that it did not produce any effect upon reddened litmus paper; but when mixed with a reddened solution of litmus, a very slight trace of alkali was discoverable.

The oxide of iron was washed until the water passing through the filter ceased to affect the solution of nitrate of barytes; the

oxide was afterwards dissolved in muriatic acid, and again tried with nitrate of barytes, which occasioned a degree of turbidness that indicated rather more sulphuric acid than would have been required to saturate the very slight trace of alkali.

It was thus proved by direct experiments that three parts of sulphuric acid are combined with peroxide of iron and one part with ammonia; it is extremely probable that the excess of sulphuric acid in the last experiment is derived from some persulphate of iron uncombined with ammonia, and upon this also depends the yellow colour, and this, as already mentioned, may be removed by repeated crystallization, a little subsulphate being deposited. The salt which I have now described is composed of

Persulphate of iron	41·807	comp. of 25·337 acid + 16·470 oxide	
Sulph. of ammonia	12·366	8·649 acid + 3·717 amm.	
Sulphate of alumina	0·870	0·610 acid + 00·260 alum.	
	55·043		

Although the quantity of water contained in the salt appeared, as already stated, to be 43·48 per cent. by direct experiment, yet it is well known to be difficult to deprive a salt of all the water, unless it be heated to redness, which the nature of this salt would not admit of. If we assume the ammonia or the sulphuric acid combined with it to be one atom, 23 atoms of water will supply the loss in the analysis, for it would amount to 44·947, and the loss is 44·457. It is, however, to be observed, that the estimate of 23 atoms of water would agree with the analysis of the salt, upon the supposition that the whole quantity of sulphuric acid belongs to it; but this is not the case; for it contains some persulphate of iron which is not combined with ammonia, and which is not united with the same proportion of water as the triple salt.

On closely examining the crystals, I observed that they effloresce slightly, and become brown on the surface. In order to decide the question, I employed Dr. Thomson's method of calculating the exact quantity of nitrate of barytes necessary to decompose the whole of the sulphate of ammonia and iron. On the supposition that it contains 24 atoms of water, 11·83 parts of sulphate of iron and ammonia would exactly decompose 13·06 of nitrate of barytes, and if only 23 atoms of water, then 11·61 of the triple salt would be required to decompose the same quantity of the nitrate. The crystals employed in this experiment were rendered perfectly colourless by repeated crystallization, and when decomposing such a portion of them by means of that quantity of nitrate of barytes which indicates the presence of 24 atoms of water, I found so little sulphuric acid remaining unacted upon, that when more nitrate of barytes was added no turbidness was occasioned for several minutes. This slight

excess of acid was, perhaps, owing to the presence of the small quantity of sulphate of alumina; for this salt contains more sulphuric acid than the triple salt, and no allowance was made in the calculation for the excess.

If, therefore, we neglect the alumina, the composition of the salt in question will be

Persulphate of iron	41·95
Sulphate of ammonia	12·11
Water	45·94
	100·00

I conceive that the salt which Mr. Cooper obtained by dissolving the oxide of iron precipitated from the pernitrate by ammonia in sulphuric acid, is similar to that of which I have now given the analysis. The quantities of sulphuric acid and peroxide of iron are nearly in similar proportions; the greater quantity of water which he assigns may be accounted for by the ammonia having been included with it.

As the results deducible from this analysis seem to agree so well with M. Mitscherlich's idea, that peroxide of iron and alumina are isomorphous, and afford additional proof of the correctness of his views, I was more particularly anxious to determine the quantity of water, with as much accuracy as possible. For although the crystals of alum belong to the *formes limités* of Haüy, which may occur in crystals of very different substances; yet if in two such compound salts there exists a close analogy between their component parts and their form, it deserves attention; and on this account I subjected alum formed of sulphate of alumina, sulphate of ammonia, and water, to analysis. One hundred parts of this ammoniacal alum were dissolved in water, and decomposed by nitrate of barytes; the sulphate obtained weighed 104·46 = 35·90 of sulphuric acid; a like quantity of the same alum decomposed by ammonia gave 11·24 of alumina. From the known composition of sulphate of alumina, it is evident that one-fourth of this sulphuric acid is not combined with alumina, and it must, therefore, be united with the ammonia, and on this supposition, the composition of ammoniacal alum will be:

Sulphuric acid	35·90
Alumina	11·50
Ammonia	3·86
	51·26
Water and loss	48·74
	100·00

Making sulphuric acid the basis of the calculation, and on account of the great weight of the sulphate of barytes the errors of experiment are diminished, we find that 24 atoms of water

are equal to 48·68, agreeing with the above result as nearly as could be expected. This proportion of water was confirmed by mixing 11·16 parts of the alum with a solution of 13·06 of nitrate of barytes, which are the proportions required by calculation on the supposition that the salt contains 24 atoms of water; there was a slight excess of sulphuric acid, but the addition of nitrate of barytes did not occasion any turbidness for some minutes.

This alum is, therefore, composed of three atoms of sulphate of alumina, one atom of sulphate of ammonia, and 24 atoms of water; and the triple salt now described consists of 3 atoms of persulphate of iron, 1 atom of sulphate of ammonia, and 24 atoms of water; or if we adopt the number assigned by Dr. Thomson to peroxide of iron, 1 atom of tripersulphate of iron, 1 of sulphate of ammonia, and 24 atoms of water.

Article III.

On Clay Slate for Road-making. By Mr. W. Stokes.

(To the Editor of the *Annals of Philosophy*.)

SIR, *Harcourt-street, Dublin.*

In many parts of Ireland is found a species of clay slate which answers remarkably well for road-making. This clay slate may be described as follows:

It occurs massive; colour of the fresh fracture, a dark bluish-grey. The colour of that which has been exposed to the air is a brownish-red. Lustre, in some places, greasy; in some exhibiting brilliant points: a few places have a blistered appearance. The fracture undulating, slaty; yields readily to the knife; it feels slightly greasy; opaque; specific gravity, 2·6. Before the blowpipe, it melts into a greenish slag.

The advantages which this stone possesses as a road material are remarkable, and might seem inconsistent were they not verified by experience.

Although easily broken it does not form light dust so as to rise with the wind; it is not readily worked into mud by carriage wheels or the feet of cattle, although roads made of other species of clay slate are very liable to this defect. Roads formed of this peculiar clay slate have an agreeable smoothness under the horse's feet, and seldom exhibit projecting stones; neither do they throw out loose stones, which is a common defect of our limestone roads. They preserve their evenness in decay remarkably, continuing smooth when only an inch of gravel remains on the surface; they are so porous that even though they have lost their central elevation, water does not rest on them.

The material is not favourable to the growth of grass, which is another advantage; roads of common clay slate and of limestone are often edged by a grassy bank, which, if it be not frequently removed, confines the water, and so forms a water-course on the road. Garden walks of this material are durable and convenient, being but little overrun with weeds, but it must be confessed they have a sombre appearance.

The districts in which this material is employed are in the county of Down, between Downpatrick and Ballynahinch, Ballynahinch and Clough Banbridge and Tandaragee, and between Belfast and Bangor; in the county of Armagh, Market Hill and Armagh, and from Armagh to Castle Blayney, in the county of Monaghan. In the south of Ireland, between Waterford and Ross.

The stone from Dunmeniss, near Ballynahinch, being submitted to analysis in the usual manner, viz. by fusing it with an alkali, yielded the following constituents:

Silica	59·4
Alumina	17·4
Lime	2·1
Magnesia	2·2
Oxide of iron	11·6
Water	6·4
Charcoal and manganese	Trace
Loss	0·9
	100·0

William Stokes.

Article IV.

Observations on Gas Light Establishments, with an Account of some Experiments made to determine the comparative explosive Force of Carburetted Hydrogen Gas and Gunpowder. By Sir William Congreve, Bart. FRS. &c.*

The first observation that arises on taking a general view of the gas works in the metropolis, is the immense extent to which they have now been carried since the year 1814, when there was only one gasometer of 14,000 cubic feet in existence in Peter-street, Westminster, belonging to the chartered company, as they were termed; the only company then established. Whereas, at present, there are four great public companies established, having, altogether, 47 gasometers at work, capable of contain-

* From Reports on Gas Light Establishments. Ordered to be printed by the House of Commons, March 26, 1823.

ing, in the whole, 917,940 cubic feet of gas, supplied by 1,315 retorts; these retorts consuming upwards of 33,000 chaldrons of coal in the year, and producing upwards of 41,000 chaldrons of coke. The whole quantity of gas generated annually being upwards of 397,000,000 cubic feet, by which 61,203 private, and 7,268 public or street lamps are now lighted in the metropolis. In addition to these great companies, who are the subject of this Report, as being placed by legislative enactment under the control of the Secretary of State, there are in the metropolis several private companies, whose operations are not included in the foregoing statements; but on which I shall feel it right to make some remarks before I conclude.

In Table, No. 8,* will be seen the details of all the above-mentioned totals; the following consideration of which will, I think, point out the importance of thus having collected these particulars into a single point of view, as tending to regulate the just price which ought to be charged to the public for the gas they consume; and, at the same time, by the general comparative view thus obtained of the whole system, as tending to induce every company to adopt the best mode of conducting its works. Presuming, and believing, as I do, in the correctness of the particulars of information given me by the different companies, as to the quantity of coal consumed in their retorts, and the average workings of those retorts during the year; it appears, by a review of these totals, either that the average consumption of gas per lamp, allowing for waste, is not so great as is generally stated; or that the quantity of gas generated from a chaldron of coals, is greater; or that the average times which these lamps are allowed to remain lighted, is not so great as reported; for if the consumption or waste of gas were equal to what is generally believed, or the quantity produced were not greater, I find that the number of lamps returned could not have been lighted for the times stated.

The general statement made by the companies of the consumption of gas for each lamp, is five cubic feet per hour; and that of the produce of gas per chaldron, something less than 12,000 cubic feet per chaldron; now allowing full 12,000 cubic feet per chaldron to be generated, it appears that the average consumption of gas per lamp in the hour by the London Company, does not exceed four cubic feet and a half; nor is the average time of burning, winter and summer, for private lamps, more than four hours; or for public lamps, more than nine hours, which is below the supposed average.

By Table, No. 8, it also appears that in the City of London Gas Works, the consumption of gas per lamp, allowing the same time of burning, is six cubic feet and a half per hour, instead of four, as above stated. It is evident, therefore, that there exists

* For this table, as well as other interesting particulars, we must refer the reader to the original report.—*Edit.*

a waste of gas in these works, which is avoided by the London Company; and, indeed, this waste is admitted at the works, and even stated at a higher rate than it thus appears to be.

The various and important checks, therefore, that may thus be obtained, show the necessity of these general investigations, and of the calculations arising out of them. I shall, therefore, in future Reports, cause a still more detailed survey of them to be made than has in the commencement of the present system of inspection been hitherto practicable.

By thus determining the actual consumption and waste of gas to each lamp, together with the expense of generating it, allowing for wear and tear and outlay of capital, which must also form the subject of future surveys, more in detail, a just estimate, not only of the actual cost of the gas to each company, but of its real value, supposing the best system to be adopted, may thus be made with a view to a fair regulation of prices, and to such other measures as the legislature may think fit to enact for the further proceedings of this great public concern.

It might have been imagined that the enormous quantity of coal thus shown to be consumed in the generation of gas, would have greatly enhanced the price and increased the quantity of coals brought into the port of London since the introduction of the gas-light system; this, however, has not been the case; on the contrary, the increase in either of these is inconsiderable, owing to the compensation arising from the quantity of the surplus of coke produced.

The quantity of coke generated, in the first instance, is at the rate of 120 or 130 chaldrons for every 100 chaldrons of coal carbonized; of this quantity, about 20 per cent. is consumed in the furnaces under the retorts, in the process of carbonization; the whole of that operation being now effected by the coke produced on the spot, without any addition of coal whatever; deducting, therefore, 20 per cent. from the increased measurement of coke produced, there remains, in measurement, nearly, or perhaps rather more than the same quantity of surplus disposable coke to be applied as fuel in the metropolis, as of coal used in the process; so that the coke seems nearly to amount to a compensation for the coal as fuel. But were the enhanced price of coal greater than it is, it could scarcely be doubted, that, as a question of economy, there would be a very considerable public saving arising out of this system, when the value of the light thus produced were set against this increased price; and certain it is, that some parts of the population of this metropolis are peculiarly benefitted by it. The poor have, by this means, access to a very serviceable fuel, at a comparatively moderate price; the coke being now sold by the companies at from 20*s*. to 30*s*. per chaldron; and the fire produced from it being, in all respects, adequate to the necessities of the lower orders.

The small rise in the price of coals, and the great fall in that of oil, may indeed be considered as a sort of measure of the saving to the public that has arisen from this application of coal; nevertheless there may be many very important considerations both of external and internal policy, which may render it very desirable that the government should give every possible encouragement to the use of the gas produced from oil. Not only our distant fisheries seem to point to the expediency of this policy, viewed as a principal nursery for seamen (which from the foregoing statement of the little increase in the consumption of coal, evidently receives no aid from the use of the coal gas) but the encouragement of our coast fisheries, as an additional means of subsistence for an increased population, renders it expedient that the utmost encouragement should be given to this mode of augmenting the consumption of oil; nor can it be doubted, that if such enhanced demand could be created for the description of oil that would thus be required, it would form a most powerful stimulus to the coast fisheries.

Thus far very little progress has been made in the extension of the use of oil gas in the metropolis since my last Report; I shall, however, state some particulars respecting this part of the subject at the conclusion of the present Report.

It is satisfactory to observe, that although considerable extensions have been made in this mode of lighting the town during the last year, no serious accident has happened: the only one indeed which deserves mentioning is that which occurred in the vaults under the Opera House, of which I transmitted a particular account at the time.

It is also satisfactory to observe, that very considerable improvements have been made in some of the processes in the different works, as well in the mode of setting the retorts as in that of charging them; and that some of the probable causes of mischief stated in my first Report have been removed; among which I may state, that the practice of making use of the coal tar in the tanks, for floating the gasometers, has been entirely discontinued.

Most of the new gasometers which have been lately erected are uncovered; by which means the probability of accident by the leakage of the gas into the gasometer houses is obviated; and the only objection that existed to making this a general practice (namely, the effect of the wind or snow in disturbing or increasing the pressure of the gasometer when exposed) is proposed to be got rid of by the addition of a small regulating gasometer, from which the mains are immediately fed.

Another very great improvement in the mode of conducting these works has been introduced in the evaporation under the retorts of the lime water, by which the gas is purified. By this means a great nuisance has been obviated which used to exist

in allowing this lime water to run into the sewers, by which a very offensive smell was produced in the neighbourhood, and a very deleterious matter conveyed into the Thames.

This mode of disposing of the lime water was first introduced by the superintendant of the Brick-lane station, and will I doubt not be very generally adopted, as this water is prohibited from passing into the sewers after the 15th February, in consequence of a prosecution carried on by the City of London against the Dorset-street Company.

Another mode of getting rid of this lime water has been experimented; viz. the purification of the gas by dry lime, which is about to be adopted in Dorset-street, in preference to the common mode of passing it through lime water.

Considerable improvements have also been made during this year in the quantity of gas produced from a given quantity of coal, which, as far as it tends to reduce the cost of the gas, not only renders a benefit to the public, but an increased advantage to the companies, in whose well-doing the public cannot but be interested, since this mode of lighting the town has now become so general, and is unquestionably attended with so many advantages to the metropolis, not only as relates to the convenience of the inhabitants, but to their security as a matter of police. This increased produce of gas has been accomplished by various means, such as the improvements in the mode of setting the retorts, in the use of a better coal, in the application of a certain quantity of the coal tar mixed with the coal in the retort.

A new description of retort, called the Graftonian retort, from the name of its inventor, has also been introduced, with the hope of further economy by the increased production of gas. This retort is made of fire brick instead of iron, and it is supposed that it will be found much more durable than the iron retort, and capable also of sustaining a greater intensity of heat, so as to render the distillation of the coal more perfect.

Other experiments have been made with a view to this same object, by the engineer of the Imperial Company, who has invented a retort, which is to be gradually fed with the coal from a hopper, so as to make the destruction of the material to be carbonized still more complete. Mr, Clegg seems to anticipate, from the experiments which he has tried, that he should be enabled by this means to destroy both the tar and ammoniacal liquor produced in the ordinary modes. He also calculates, that by these means the quantity of gas produced will be increased to 16,000 or 18,000 cubic feet per chaldron, and that it will moreover be of a superior quality, so as to give considerably more light in proportion to the quantity burned. It would certainly be very desirable to get rid, as much as possible, of the different products resulting in the distillation, excepting the coke, as some of them do not pay for their removal, and are liable, there-

fore, to be left for some time on the premises, so as to become more or less nuisances to the public.

At present the system is far from perfect in any respect. It is hoped, therefore, that every possible encouragement will be given by the different companies to that description of investigation and experiment calculated to promote improvement, although no immediate profit may result to the companies.

It is also very desirable, that when any improvement is realized by any particular company, that it should be generally adopted by the rest; and by the due exertion of this spirit, I have but little doubt that a great degree of perfection, both as to convenience and security, may be looked for at no distant period.

Great care, however, is unquestionably requisite, and there are certain points, the observance of which by the different companies is so essential, that any indifference or neglect as to them must be vigilantly prevented; for it must be obvious that the vast accumulation of inflammable gas necessary to carry on this mode of illumination, in its present extended state, must be attended with more or less risk, according to the conduct of those employed. To explain, therefore, somewhat more definitely than has hitherto been done, the nature and extent of this risk, I have caused the following experiments to be tried at Woolwich since my last Report, with a view to bring the explosive forces of different mixtures of carburetted hydrogen and atmospheric air into a comparison with gunpowder.

The results are as follow:—The following mixture was fired from a cylinder constructed for this purpose, to project a ball weighing 7 lbs. 2 oz.; the cylinder being suspended by a pendulum, to measure the degrees of recoil.

First experiment.		Feet.	Average recoil of cylinder.
Carburetted hydrogen, 288 cubic inches, and 1,440 cubic inches of common air, being in the proportion of one-sixth of hydrogen to five-sixths of atmospheric air, were fired.	Ranged the ball, on an average of three rounds.	94	64°
Gunpowder (8 drachms) was found to produce nearly the same effect.	Average range of the same ball.	77	64

It appears, therefore, that mixed in this proportion, viz. one-sixth of carburetted hydrogen to five-sixths of common air, one cubic foot of this gas would be equal to three ounces of gunpowder; that 480 cubic feet are, therefore, equal to one barrel; and that the contents of one gasometer of 15,000 cubic feet are

equal to 31 barrels. Fifteen such gasometers, therefore (the number in Peter-street), would, with this mixture, produce a force equal to that of 465 barrels of gunpowder.

A second experiment was subsequently made with a greater proportion of the carburetted hydrogen.

Second experiment.		Feet.	Recoil of cylinder.
346 cubic inches of carburetted hydrogen, and 1,382 cubic inches of common air, being one-fifth to four-fifths were fired.	Average of three rounds with the same ball.	158	76°
16 drachms of gunpowder were found to produce nearly the same effects.	Ditto, ditto.	113	74

One cubic foot, therefore, of gas, mixed in this proportion, would give an explosive force equal to five ounces of gunpowder, or 288 cubic feet equal to one barrel; one gasometer, therefore, of 15,000 cubic feet so mixed, would be equal to 52 barrels and a quarter, and 15 such gasometers to 783 barrels and three-quarters of gunpowder.

For the mere purpose of determining the risk of large accumulations of carburetted hydrogen gas, it was evidently unnecessary to try any further experiments, since it was thus proved, that if by any accident the contents of one of the gasometers in Peter-street were to be supposed to have escaped into the gasometer-house, so as to form a mixture with the surrounding atmosphere, in the proportion of one-fifth of gas, an explosive mixture would be created equal to upwards of 50 barrels of gunpowder; and that if the contents of the whole of the gasometers at this station could be supposed to have escaped in like manner, an explosive force equal at least to 700 barrels might be created; and that on the same principle, the entire leakage of one of the large gasometers of 30,000 cubic feet in Dorset-street, might produce an explosive mixture equal to about 135 barrels of gunpowder.

It is true, that in the ordinary condition of the carburetted hydrogen contained in the gasometers, it is not explosive; it wants the admixture with common atmospheric air to make it so; but then it must not be forgotten, that this requisite ingredient is the circumambient atmospheric air, that surrounds the gasometers, and is in constant contact with every part of them, so that the union of the two ingredients in certain dangerous proportions may always be effected, either internally or externally, by unforeseen accidents; as the destruction of a gasometer by lightning, producing both the mixture and the ignition at the same moment; the same by the burning of the gasometer-

house; by the oversetting of a gasometer, from the breaking of its chain of suspension, an accident which lately happened at Brighton, and which has happened also by the bursting of the tank in which the gasometer floats. The constant leakage of an old gasometer is also a probable cause of explosive mixture. At all events, these are evidently probabilities of accident quite sufficient to show the absolute necessity of the utmost vigilance and precaution.

But even supposing this mixture not to take place, I apprehend that serious consequences might attach to the mere inflammation and combustion of a large deposit of inflammable air, even in an unexplosive state.

It appears to me, that such a combustion, by lightning or otherwise, would produce very destructive effects to the neighbouring buildings, and gasometers, merely by the sudden rarification and expansion of the air caused by it, and would, in fact, produce a violent detonation and concussion, without supposing any combination of oxygen and hydrogen, but merely by the simple conflagration of the hydrogen; under these circumstances, and especially with reference to the experiments made at Woolwich, by which it appears, that the explosive force is greater than has usually been assigned,* I shall feel it right in concluding this Report, distinctly to point out such precautions, in this and in other respects, as I think ought to be enforced for the security and convenience of the public.

In viewing the probable causes of disappointment to the public which might occur from the want of the due management of this now greatly extended concern, I have been induced to make very particular inquiries as to the probability of the stoppage of the pipes, by which the gas is conveyed to the different parts of the metropolis. The result is certainly satisfactory, as I find that in the cast iron pipes or mains not the smallest deposit or corrosion takes place; there is, however, a very considerable tendency to stoppage in the service pipes, which are made of wrought iron, insomuch, that many of these pipes have been found completely choaked up in four or five years use.

The pipes, also, in the interior of the shops and houses, and for the immediate conveyance of the gas to the lamps, which pipes are generally made of copper, are liable to stoppage by internal corrosion. The wrought iron service pipes may, however, be conveniently replaced by lead, which is not subject to this deposit, and the copper pipes by those of block tin, both of which have been so used with good effect.

It is satisfactory, therefore, to observe, that that which would be a general and extensive evil (if there existed any liability of stoppage in the mains), has no existence at all, while that which is comparatively a less evil, being merely partial, may be easily

* Probably from the experiment having been made on a larger scale than any before tried.

remedied, by the substitution of one material for another. These are, therefore, points to which the attention of all the companies should be directed.

It is further also to be observed, that as the deposit by which these pipes are liable to be stopped, is a sulphate either of iron or copper, this evil may be greatly diminished by the greater purity of the gas.

This, therefore, becomes an additional reason for urging the utmost attention to the process of perfectly purifying the gas previously to its entering the pipes, independent of many other advantages, such as the diminution of its offensive odour in every part of its course and application, and of the mischief which occurs to gilding, furniture, &c. in the rooms in which impure gas is burned.

Regulations which it appears important to enforce.

Enough has already been stated on the probability of accident and the extent of danger, to prove the necessity of enforcing certain restrictions as to the quantity of gas suffered to be accumulated within a given space; by which restrictions not only the size of the gasometers hereafter to be constructed, or the quantity of gas to be allowed to be admitted into those already constructed, shall be limited, but by which also the proximity of these gasometers to each other shall be regulated, as well as their distance from any inhabited buildings. I shall now, therefore, proceed to the consideration of these restrictions.

Much unwarrantable and inconsiderate extension has proceeded in all these respects since the first Report of the Royal Society on this subject in 1814; and it may not now be practicable, without exceedingly embarrassing the companies, and, consequently, inconveniencing the public, both as to the price and as to the supply of gas, to make any immediate reform; but I have no hesitation in saying, that the gasometers now generally in use contain a much greater quantity of gas than can be accumulated with perfect safety; and that they are placed much too near to each other, and too near to some of the most populous parts of the town.

The recommendation contained in the Report of the Royal Society in 1814, limited the size of the gasometers to 6000 cubic feet; the expense, however, attending this limitation, from their contents being so small in proportion to their surfaces, is such, that I conceive it might be expedient to seek for an equivalent security by other precautions, and to allow a greater latitude as to the magnitudes of the gasometers. Taking, therefore, ample space around each gasometer, I do not know that there would be much to apprehend from the use of gasometers measuring about 20,000 cubic feet, and working between 15,000 and 20,000 of these feet; but with such quantities in each, I am decidedly of opinion, that these gasometers should not be placed nearer

to each other than 40 feet, or about a diameter of one of the gasometers; and that if they are nearer, a strong brick traverse should be immediately erected between them, similar to those used in the powder works at Waltham Abbey. I am decidedly of opinion also, that these gasometers should not be suffered to exist nearer than from 50 to 100 yards to any dwelling-house, without being similarly traversed.

But under such restrictions, I should consider the safety of the town as well provided for in respect of the gas works, as by that regulation relative to the quantity of gunpowder allowed to be stored in any warehouse, which limits that quantity to two barrels.

In carrying this restriction, as to the size of the gasometers, into effect with as little inconvenience as possible to the companies, I should recommend, as the readiest and cheapest mode, that where larger gasometers exist, their altitudes should be diminished, or, at least, that they should not be allowed to work these gasometers above a certain altitude; and that if the expence of reducing their depths were desired to be dispensed with, some permanent stop should be applied to them to prevent their rising above a certain height, so as to contain more than the limited quantity of gas. I should recommend also, that where these gasometers are, as in many of the establishments is the case, nearly close to each other, every other one should be taken out and removed to a distance; nor need this involve any necessary increase of ground *on the spot* where the gasometers are now placed (the purchase of which, in some cases, might be impracticable), but merely a removal of these gasometers to a distance; the communication with the retorts, &c. being, as it may be, without difficulty, effected (and as, in fact, it now is at the South London Works), at a distance by pipes under ground. I should also recommend, that a general regulation should be enforced to prevent any gasometer being placed within 50 yards of any retort or other part of the works in which fire is used. Such appear to me to be the principal regulations necessary as to the size and situation of the gasometers; and it was on these principles, in a reference lately made to me by the Lords Commissioners of the Treasury, of an application from the Imperial Gas Light and Coke Company, for permission to purchase an additional quantity of land, that I recommended that this permission should be granted, although it had, in passing the Acts of Parliament, been considered desirable to limit the grants of lands, that the works might not be erected on too large a scale.

My view of this subject is, that it may be quite right to limit the quantity of gas generated in particular works; but that I certainly would not limit the quantity of ground on which the apparatus, for its generation, is to be erected.

With reference to the particular construction of the gasometers and gasometer houses, from all that I have been able to

ascertain, I should recommend that the gasometers should be erected in the open air, or, at all events, with the slightest and most ventilated covering possible, seeing that there is much greater chance of explosion in the gasometer house, where a very small leakage of gas from the gasometer, may produce the explosive mixture, than in the gasometers themselves, into which large portions of atmospheric air must find their way to create danger; and this I am the more induced to recommend, since I find that a remedy has been devised for all the inconveniences that might otherwise be apprehended by the intervention of a small regulating gasometer between the principal gasometers and the mains, as already stated; an arrangement which, it appears to me, ought to be generally adopted, as it would also be attended with other good effects, in addition to those abovementioned; among which may be noticed the prevention of accidents from the irregular flaming of the lamps in shops, and especially that very serious cause of accidents in such situations, which was noticed in my first Report as being likely to occur from the falling of a gasometer at work, supposing its chain to break, by which, in the present state of the works, the flame of the lamps connected with that gasometer would, on a sudden, be made to blaze up to so great a height as could not but be attended with the most serious consequences in a great variety of situations; all of which accidents would be entirely prevented by the regulation in question.

In the foregoing general observations, I have stated the liabilities to stoppage by corrosion, which exists in the wrought iron service pipes in the streets, and also in the copper feeders in the inside of the houses; and I have there mentioned the facility which, fortunately for the perfection of this system, exists, of getting rid of this inconvenience by the substitution of leaden and block tin pipes; I shall now add, as an important regulation for the general adoption of which, I conceive, the government should exert its authority; that all the gas pipes, whether mains or services, ought to be laid in a bed of clay, firmly rammed round the pipe. The necessity of this regulation not only manifests itself constantly in walking through the streets of the metropolis, from the frequent recurrence of offensive smell arising from the leakage of the pipes; but was clearly proved by the accident which happened in the wine vaults under the arcade of the Opera House, into which the gas had found its way from a leak in a service pipe passing over the crown of this vault, though no gas was laid on in any part of the premises. The recurrence of much accident, and the general nuisance above stated, would be effectually guarded against by this coating of clay round the pipes; in addition to which, a saving of gas now lost by leakage, would ultimately accrue to the companies. The expense, in the first instance, might be considerable, and, it is to be regretted, that it was not originally attended to, because it

would not certainly be now advisable, generally, to break up the streets for that purpose; but I should distinctly recommend, that whenever new pipes are laid, or old ones exposed for repair or otherwise, this measure should be universally enforced.

There is another subject to which I feel it right to call the serious attention of the government, conceiving that some general regulation in this respect would be a material benefit to the public, as well as to the companies.

I allude to the limitation of particular districts to particular companies; at present, as may be seen by the accompanying plan, the mains of more than one of the first-formed companies, principally the London and City of London Gas Light Companies, are carried into the same district, and indeed in many places into the same streets, lanes, and even alleys, so that adjoining houses, in the most confined situations, are frequently supplied by different companies, the pipes of these different companies intersecting and mixing in a very complicated manner.

From this it frequently happens, that in case of the nuisance of leakage, it is unknown from what pipes this nuisance proceeds. A hesitation is thus, therefore, constantly manifested as to which company is to open the ground; disputes arise, and much delay and inconvenience is the consequence, not only from the nuisance being thus prolonged, but from the more frequent breaking up of the pavement, naturally arising from a double set of mains and services than if only one set were allowed in the same district.

The only argument, as it appears to me, that could be adduced against this limitation, would be as to any supposed effect that might arise from the encouragement of the competition of different companies in keeping down prices; but this objection I apprehend may be settled, by regulating the general prices with less difficulty than exists in the present state of the supply. And this regulation of prices, as I have already stated, is one of the advantages that may be fairly calculated upon as an early result from the due exertion of the control of the government.

Some of the companies, from the complaints, disputes, and other inconveniences, attending the present arrangement, are very desirous of entering into a compromise for the limitation of their districts, and have offered an exchange of mains, &c. value for value; and I must confess that it appears to me advisable, that a general regulation on this subject should be adopted as soon as possible. The latter charters indeed have proceeded upon this principle. The Imperial Company, for instance, is thus limited to particular districts, and those districts are exclusively granted to them.

I shall now only state one more regulation, which I think it would be very important to have enforced, that not only should accurate plans of the present actual state of all the gas works

in the metropolis be transmitted to the person charged with the general inspection of them, but that no new work, nor any extension of old works, should be proceeded upon until regular plans of them shall have been laid before the inspector, and until the sanction of the Secretary of State shall have been procured by him for their proceeding.

It is but right that I should take this opportunity of stating, that I have received every facility and attention on the part of the directors of the different companies to my requests for information; but I have not yet been favoured with plans, such as those above-mentioned, without which it is impossible to enter with that accuracy into all the details of such a survey, which the magnitude, risk, and general importance of these works demand. It is indeed evidently the interest of the companies concerned, to furnish as early as possible, before they undertake new works, plans of their intended operations, inasmuch as prevention is better than remedy, and that it is easier to make alterations in a drawing than in a building; nor can I refrain from repeating, that it is much to be regretted that such an arrangement was not long since carried into effect, as the thorough security of the town and the perfect organization of the system might have been insured, at a much less expense to the companies than will now be ultimately required.

On this part of the subject it remains only that I should state, that having thus far, at the request of the government, devoted myself to the consideration of this important public concern, I am ready to proceed in giving my best assistance in seeing that those preventions, which I have suggested for the safety of the metropolis, are properly carried into effect, in the performance of which I should feel it incumbent upon me, equally upon public grounds, to consult the interests and accommodation of the companies as far as it could consistently be accomplished with reference to the primary object, the convenience and security of the public.

On the subject of the coal gas works, it remains only to be observed, that there are several private gasometers erected for the lighting of manufactories and other buildings, where the operation is confined entirely to the particular premises, such as the Royalty Theatre, Messrs. Ward and Ainger's, south side of Blackfriars-bridge, and many others.

There are other coal gas works also formed, not only for the purpose of lighting particular premises, but which extend their operations by the sale of the gas for lighting the neighbouring buildings also.

And there are other private establishments created entirely for the sale of coal gas to the public. The mains of some of these works extend to very considerable distances. The Ratcliffe Company, for instance, have three gasometers, and have brought their mains nearly up to the Tower of London. Ano-

ther of these factories is formed at Poplar, and another in Cromer-street, Brunswick-square.

It does not, however, seem necessary that I should now go into any further details respecting these works, though it is important that I should state that they have been established *entirely without Act of Parliament or other licence*, and that it appears to me, as these works are liable to accident and nuisance, as well as those carried on upon a larger scale, though not, perhaps, the same extent, that they ought also to become the object of such rules and regulations as the government may deem it expedient to determine upon for the conduct of the principal works—and that no gas works whatever should be allowed to be formed without a licence in the first instance, and without being subjected to subsequent inspection and control.

Oil Gas Works.

I ought not to close this Report without adding a few words more on the subject of oil gas, although there is no part of the application of this modification of the system, which at present regularly falls within the scope of this Report.

I am sorry to say, that but little extension in this branch of the gas lights has taken place in the metropolis since my last Report, although it has been adopted by some of the largest provincial towns, namely, Liverpool, Plymouth, Cambridge, and Taunton, and, as I understand, Dublin also.

In London one public company* only has been established, which is situated near Old Ford; these works consist of one gasometer, 30 feet in diameter and 12 feet deep, supplied by 12 retorts, of which, however, not more than three or four are at present kept in action, as the quantity of gas consumed does not exceed 6,000 cubic feet daily.

These retorts are charged only once a day, a continued small stream of oil being kept constantly dropping into them.

One gallon of oil is calculated to produce 100 cubic feet of gas, the illuminating power of which is stated to be equal to more than 300 cubic feet of coal gas.

The oil gas requires only to be passed through a cistern of oil for its purification. The oil undergoes no change in the process, so as to deteriorate it, or render it offensive, like the lime water used in the purification of coal gas, neither is there any residuum left in the distillation by which a nuisance can be created.

Oil of any inferior description is capable of producing good gas, though some of the vegetable oils are the best.

About seven miles of main are attached to these works, running from the London Hospital, Whitechapel, to the four mile-stone, Stratford.

* The capital granted to this company by Act of Parliament is 10,000*l.* of which 6000*l.* has been already raised.

Each house served with this gas is furnished with a small gasometer, to measure the quantity of gas consumed, for which the consumer pays at the rate of 5*s.* for 100 feet.

There can be no doubt that the light thus produced by oil gas, taking the different intensities into the account, is much cheaper than that produced by the direct burning of oil; nor indeed is the expense of oil gas greater than that of coal gas, if we admit the intensity of its light to be three times that of an equal quantity of coal gas, or that one burner supplied with oil gas is equal to three with coal gas.

The charge for 1000 cubic feet of coal gas is 15*s.*; and the expense of 3000 feet of coal gas, therefore, is 45*s.* which is stated to be *scarcely* equal to 1000 cubic feet of oil gas costing 50*s.*; now if the values in proportion to the light obtained thus nearly approximate, it certainly appears to me, that the oil gas must be nearly, if not quite as cheap, taking into the account the great reduction in the first outlay for the apparatus required for generating the oil gas, computed to that required for the coal gas, and reckoning also the difference in the required size of the mains. And indeed the extensive introduction of this system into the provincial towns now going on, is to my mind a convincing proof of the correctness of the foregoing statement, and makes it only matter of greater surprise to me, that so little has yet been done as to the public use of oil gas in the metropolis, the more especially when its greater security, from the reduced quantity necessary for a given light, its greater purity, and less offensive smell, are taken into consideration.

I must not, however, omit to say, that an oil gas company, called The Portable Oil Gas Company, is about to be formed in London. The principal object of this company is to supply detached houses with this gas, in situations where no mains are laid down. For this purpose strong copper vessels are prepared of different dimensions, in which the oil gas is deposited by compression; so that a vessel of one cubic foot has been made to contain 16 cubic feet of this gas; and if each cubic foot of this gas is supposed to be equal to three cubic feet of coal gas, then would such a vessel contain oil gas sufficient to supply one lamp for nine hours.

The idea is in some cases to attach a vessel containing a considerable supply on this principle to small feeding pipes leading to fixed lamps in different parts of the building; and in some cases, to have the reservoir containing the condensed gas, made part of a moveable or portable lamp.

The first of these modes seems to me most likely to be useful, limited, however, as above-mentioned, to situations where no mains are laid on, and where it is desired to avoid the trouble of generating the gas on the spot.

The latter seems to be still more limited in its application, as few moveable lamps could be conveniently constructed, which

would allow of a reservoir being attached to them sufficiently capacious for general uses.

These plans are certainly very ingenious, though it cannot be denied that there must be considerable inconveniences and expenses attaching to the constant removal of the reservoirs between the factory where the gas is to be generated and compressed, and the house where it is to be consumed; nevertheless, I am informed, that a considerable capital has been already subscribed to carry the project into effect.

To this spirit of enterprise it must be left to overcome the difficulties of the undertaking; I have only to consider the danger; and to this, as the scheme advances, it will be my duty, or the duty of whoever undertakes this inspection, to look seriously and to call the attention of the government; for here unquestionably we find introduced a new description of danger altogether; in the highly compressed state into which it is found necessary for the sake of portability to condense the gas. There is evidently *some risk* in forcing 16 atmospheres into a light copper vessel, when *quite new;* but when such vessel has been long in use and long strained by the constant efforts of the confined gas, the danger of its bursting must be considerably enhanced.

Precautions may it is true be taken to render an explosion as little mischievous as possible, and the vessels may be calculated of ample strength in the first instance; yet it is difficult to ascertain the probable effects of accidental explosion, or the constant strength of materials, and more especially where the compression first given to the gas is liable to subsequent increase by heat.

With respect to the oil gas it remains only to be stated, that though so little extension of it in public works has taken place in the metropolis, its use has been considerably advanced in private establishments; and I shall conclude by offering it to consideration, how far all these applications of this gas, as well as of the coal gas, ought to be subjected to some sort of licence and regulation.

William Congreve.

Article V.

On the Development of Electromagnetism by Heat. By the Rev. J. Cumming, MA. FRS. and Professor of Chemistry in the University of Cambridge.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR, *Cambridge, April 30, 1823.*

The following, selected from some experiments which were the substance of a paper read at the last meeting of the Cambridge Philosophical Society, as, I believe, they are new, will, I hope, be found interesting to your readers.

All the metals, not excepting fluid mercury, produced a deviation on the magnetic needle of a galvanoscope, provided the extremities of the metallic bars employed were at *different* temperatures.

It was indifferent whether the connecting wires were united to the bars by soldering, rivetting, or simple contact.

Bismuth and antimony (the metals which seemed most efficacious) gave with copper wires, deviations in opposite directions.

A bar of bismuth four and a half inches long, half an inch broad, and one-eighth thick, gave a *positive* deviation of 21° on a compass needle, four and a half inches long, at the melting point of bismuth; at 180° and 100°, the deviations were respectively 12° and 5°, the cooler end being constantly at 60°.

A similar bar of antimony, with the utmost heat of a spirit-lamp, gave a *negative* deviation of 19°.

When a few drops of ether were made to evaporate from one extremity of these bars, the other being kept at a constant temperature of 60°, deviation was produced, but, of course, in the opposite direction.

A slip of palladium, weighing 35 grains, having silver wires rivetted into it, when made red-hot at one extremity, gave with a small compass needle a deviation of 70° *positive;* with platina wires 10° *negative.*

A similar slip of platina with silver wires gave a *positive* deviation of 65°; with platina wires 4° *negative.*

A bar of zinc cast upon copper wires gave a negative deviation of 45°; the same bar with zinc wires gave a deviation of 2°; with silver wires a deviation of 2°; and with iron wires a deviation of 3°, all positive; but with platina wires a deviation of 50° negative.

A copper bar with zinc wires gave a deviation of 20°; with copper wires a deviation of 10°; and with silver of 30°, all positive; but with platina wires a deviation of 18° negative.

A small silver bar with silver wires gave a positive deviation of 20°; but with platina wires 50° negative, both at a red heat.

A brass bar with platina wire gave 10° negative deviation; with silver wire 20° positive; with brass wire 15°, and with zinc wire 25°, both positive.

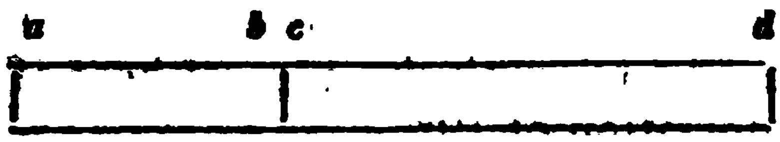
An iron bar with brazed copper wires, and the heat of two lamps, gave 45° of negative deviation; it likewise deviated negatively with wires of platina.

Two connecting wires, each composed of a platina and a silver wire soldered together at one of their extremities, were rivetted into a copper bar: when the silver ends were rivetted to the bar, the deviation was *positive;* when the platina, *negative;* but when the platina ends were shortened to half an inch, the deviation again became *positive.*

Quicksilver inclosed in a glass tube, eight inches long, and half an inch in diameter, with copper wires, gave at the temperatures 170° and 115° the corresponding deviations 8° and 3° with the small compass.

A double bar, eight inches long, composed by soldering together at the middle a bar of bismuth and another of antimony, when heated at *both* extremities, and kept at a temperature of 60° in the middle, gave a deviation of 36° with the large compass at the melting point of bismuth.

An alloy of bismuth and antimony gave with the large compass a deviation of 8° *negative;* on continuing the heat it returned to zero, and at the melting point of the bar, it became 4° *positive.*

A bar of bismuth, six inches long, was broken into two parts; 

, *a b* and *c d* of two inches and four inches in length, and soldered together again with a thin plate of copper interposed. When heated at *a* or *c*, the deviation was *positive;* and when at *b* or *d*, was in the opposite direction; but when the bar was unbroken, the deviations had been in the same direction, whether the heat were applied at *a*, *b*, or *c*.

A rod of bismuth having wires soldered to it in different parts of its length, the included portions being alternately hot and cold, exhibited as many poles as there were wires.

Two bars, whose deviations were respectively 20° and 16°, when connected in sequence gave a deviation of 23°; the deviation was not so great when the hot and cold ends were connected respectively.

A battery of eight bars produced some, but not a considerable increase of power.

A bar which produced a deviation of 20° with four feet of copper wire, of 1-21 of an inch diameter, gave, with 8, 16, and 32 feet of the same wire, corresponding deviations of 15½°, 10°, and 7°.

With eight feet of copper wire, of 1-27th inch, the deviation

was $6\frac{1}{4}°$; with the same length of platina wire of 1-100th inch, not more than $\frac{1}{8}°$.

With four feet of copper wire of 1-12th inch, the deviation was 21°, and was not increased by using two such wires.

In all these experiments, the deviation was in the same direction throughout every part, both of the bars and of the connecting wires.

No difference of effect was observed, whether the bars were after fusion cooled slowly or rapidly.

The effects were not materially increased by increasing the dimensions of the bars, or of the surfaces in contact.

A tourmaline, which by heat exhibited the opposite electric states very strongly, produced no deviation on the magnetic needle, when its ends were connected with the galvanoscope by silver wires coiled round them.

For a comparison between the electromagnetic effects as produced by heat and by the usual process, it was observed that rods of zinc and copper, each 7-10ths of an inch in diameter, and distant 4-10ths, when excited by equal parts of muriatic acid and water, produced a deviation of 27° on the large compass; and rods of 3-10ths distant 3-10ths inch, gave 40° with the smaller. Believe me, dear Sir,

Very sincerely yours,

J. Cumming.

Article VI.

Experiments to determine the Practicability of an Operation for Phthisis Pulmonalis, proposed by Dr. Carson. By David Williams, MD.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Liverpool, May 4, 1823.*

The following experiments were instituted from a desire to examine a very important physiological hypothesis, advanced by Dr. Carson. That gentleman has published a pamphlet,* consisting of three essays: one, on the Elasticity of the Lungs; another, on the Vacuity of the Arteries after Death; and the third, on Lesions of the Lungs. In the second, or that on the Vacuity of the Arteries after Death, he relates two methods that he adopted for killing animals, by admitting air through different parts of the parietes of the chest into both its cavities simultaneously, thereby collapsing the lungs. One method was by making an opening of about an inch in length between a pair of the ribs on each side of the thorax. The other was by making

* Essays, Physiological and Practical. By James Carson, MD.

an opening fit to admit his two fingers from within the abdomen, through the muscular part of the diaphragm on each side; instantaneous death was the result of the latter method in all his trials. In the former, death was not less certain, though a little more tedious; the life of one animal only (a large dog) was protracted so long as twenty minutes. In his third essay, or that on Lesions of the Lungs, Dr. Carson details an experiment performed on three rabbits as follows: An incision was made between two of the ribs on one side into the cavity of the chest, the air was freely admitted, and he concluded that the lung must have been reduced to a state of collapse. The wound was then allowed to close and heal. At the distance of five days, a similar opening was made into the cavity on the opposite side, when one out of the three rabbits soon expired after the second operation. Dr. Carson inferred from the results, that it is possible to collapse one of the lungs, and to retain it in that state, *ad libitum*, by keeping open the communication between the cavity of the chest and the external air; and further, that upon allowing the opening to close, the lung in a given time will recover its wonted function, thereby rendering it practicable, when conceived necessary, to place the opposite lung under the like discipline. Dr. Carson has very ingeniously proposed the application of his views to the cure of one of the most frequent and fatal of diseases, phthisis pulmonalis; and in a single instance, he has reduced his hypothesis to practice, by sanctioning the operation upon a patient in this town.

It will be, perhaps, rather difficult to reconcile with the above, the results of the following experiments: indeed had I not been indulged with the presence of medical gentlemen at several of them, I should have felt some scruple in giving them publicity. All the subjects of my experiments were dogs. The first four noticed had their os humeri secured to the rings of 56 pound weights; their hind legs were well extended, and fastened to similar weights; so that they were retained nearly in their natural standing position, which preserved to them, in a great measure, the use of their auxiliary respiratory powers.

Exper. 1.—An opening to the full extent of an inch was made into the left cavity of the chest, between the sixth and seventh ribs, midspace, betwixt the spine and sternum. At each inspiration, the lung was partially inflated, and was distinctly seen beneath the orifice, and at a little distance from it. At each expiration, it evidently contracted, and its lower thin margin was thrust outward through the aperture, with great force and a peculiar noise, caused by the protrusion, and an exit of a portion of the air. The breathing was distressed when the lung protruded, but as soon as the wound was allowed to contract, it became more tranquil. The right cavity was in like manner opened, and the same phenomena were observed. When both apertures were kept wide open, the breathing was very laborious

and distressing, which did not arise altogether from the presence of air in the cavities, but principally from the violent protrusion of the inferior margins of the lungs, because the instant the openings were permitted to contract, so as to prevent that accident, respiration became more easy. About ten minutes after, the second opening was made, before the lips of the wounds were brought together. The dog, when let loose, walked, was weak, but breathed easy; would taste nothing until the next morning, when he appeared lively, took his food, and regained his strength daily. The ninth day after the operation, he was hanged, and the trachea tied, to prevent the collapse of the lungs, on opening the chest. Dissection: no morbid appearance in the cavities of the chest; the wounds were healed internally, but not quite externally. The lungs did not reach by two inches the lowermost part of their cavities, nor did their bulk appear equal to the filling of the other parts of their cavities.

Exper. 2.—Dr. Traill, Mr. Christian, and Mr. Dawson, surgeons, were present. The operation was performed in the same manner as the first; the openings were better than an inch in length: both lungs wounded in the operation in consequence of the dog struggling (his hind legs not being sufficiently extended). The lungs did not protrude, but the wounded part of the one that was most seriously injured by the knife was observed to present itself at each expiration opposite the aperture. Will a wounded lung protrude under every circumstance that a sound one will? The above medical gentlemen were convinced that the lungs only partially contracted, and that they were not in a quiescent state, but that respiration more or less oppressed, according as the openings were expanded, continued uninterruptedly during the experiment. A silver catheter introduced into the chest was moved about by the alternate contraction and distension of the lung. The dog was detained with both apertures wide open for the space of five minutes; then untied, without bringing the edges of the wounds together. He was rather lively, shook his tail, drew himself upon his belly along the floor, then lay down on one side, and contracted himself, as if to close the openings; whether it was instinct or accident that induced him to choose that position, it certainly had that effect, thereby enabling him to breathe easier; though his breathing, after he was let loose, did not appear much distressed, his strength was considerably exhausted. About an hour after, the edges of the wounds were brought together; during the intermediate hour, the external air communicated with the cavities. He refused his food until next day, when he recovered his appetite, and regained his strength apace. The fifth day after the operation, the dog was hanged. Dissection: the internal edges of the wounds healed; the left lung had a deep plum-coloured circular spot, as large as the circumference of a crown piece,

surrounding the wounded part, which was quite healed. On making an incision into the discoloured portion, it was found gorged with blood, without any apparent disorganization, and appeared in a fair way of regaining its natural state. A similar spot surrounding the wounded part was observed on the right lung, but smaller; that wound was also healed, no adhesion or extravasation in either cavity. Absorption must have been very rapid, as a considerable effusion of blood into the left cavity had taken place during the operation.

Exper. 3.—In the presence of Drs. Jeffreys, Jardine, Nicholson, and Messrs. Blackburn and Jones. An opening of an inch and a half in length was made between the sixth and seventh ribs on both sides of the thorax, of a middle-sized cur. The air had free ingress during inspiration; and at each expiration, it rushed out, the lungs frequently protruding, when not prevented by the examinations of the above medical gentlemen. The breathing was much distressed; the animal was kept on the table for five minutes, after both the openings were made; when let loose, he walked about, apparently but little affected, the air passing in and out of the cavities. At the expiration of ten minutes from the time he was liberated, the apertures were fully distended, and retained so by applying and pressing a finger at the extremity of each of them, which effectually prevented the ribs from approaching each other; in fact, in my opinion, they were fixed. The death of the animal took place in less than two minutes. To what extent the auxiliary respiratory organs were impeded in their action by the two ribs on each side being retained asunder, I cannot say; but if they were impeded, and I think it is evident that they were, the death of the animal naturally must have been accelerated.

Exper. 4.—In the presence of the same gentlemen as witnessed the latter. A small opening was made into each cavity of the chest of a bull-dog in the intercostal spaces, and a full-sized clyster-pipe introduced into both apertures, which were retained for half an hour in an oblique position, their internal ends pointing towards the upper part of the thorax; during which time air freely passed inwards and outwards. The animal was occasionally distressed in his breathing, when he would struggle and contract so as to force out as much as possible the air in the bags of the pleuro; then he would make a quick and full inspiration, by which he was considerably relieved. After regaining his liberty, he seemed but little injured by the operations.

Exper. 5.—An opening five inches in length was made between the sternum and symphysis pubis into the cavity of the abdomen. The diaphragm appeared tense, and the action of its fibres were visible, but confined, from the very great pressure required to prevent the protrusion of the intestines, &c. The

violent thrusting outward of the contents of the abdomen was principally, if not entirely, occasioned by the action of the diaphragm, for the force of the protrusion diminished as soon as its action was obstructed on one side of the mediastinum, and ceased when it took place on both sides. With a little difficulty an opening about an inch in length was made into the left cavity of the chest through the muscular part of the diaphragm, three inches below its attachment to the ribs. When the air rushed in, the diaphragm on that side became relaxed, and its action not only obstructed, but its irritability to all appearance suspended. A portion of the diaphragm jutted out towards the abdomen, and formed a pouch, with the aperture in its centre. A similar opening was made into the right cavity of the chest, followed by the same effects. An ivory tube, 3-10ths of an inch in diameter, was repeatedly introduced into each aperture. The diaphragm seemed to be altogether guided by the action of the contiguous parts, and by the pressure and passage of the air modified by respiration; at each inspiration it was drawn towards the chest, and expanded by the dilatation of the thorax, but its expansion was not sufficient to obliterate the pouches before noticed, which was a strong proof, together with the quiescent state, compared with the previous violent thrusting outwards of the contents of the abdomen, of its paralysed condition. Is it not likely that in many wounds penetrating into the cavity of the abdomen, unaccompanied with thrusting outwards of its contents, that the diaphragm is wounded? At each expiration, the diaphragm was pushed towards the abdomen, by the pressure and passage of the air from within the cavities of the chest, and the pouches enlarged. The breathing was oppressed, but not so distressing as in the first three experiments, when the apertures were wide open. The external wound was brought together by suture. When the dog was removed from the table, he walked, but tottered a little; he breathed easy, and three hours after lapped some milk, which was rather surprising, as the first two operated upon would accept of nothing until the following morning. He recovered his strength and liveliness amazingly fast. On the third day after the experiment, he was hanged, together with another dog not operated upon, for the purpose of comparing the appearances of their respective lungs. Each had his trachea secured immediately on being cut down, before the suspending cord was slackened, to prevent collapse of the lungs on opening the cavity of the chest. Dissection in the presence of Dr. Traill, to whom I am greatly indebted for many suggestions in conducting these experiments. No morbid appearance in the abdomen, with the exception of a few adhesions between the liver and peritoneum; the apertures in the diaphragm were closed by a tender film, which very readily gave way to the probe. On opening the chest, the heart was once observed to contract, and the pericardium was perfectly trans-

parent, as remarked by Prof. Richerand.* We could perceive very distinctly the ramifications of the coronary vessels; the diaphragm was in its natural position; no adhesions; the lungs on first exposing them appeared perfectly smooth and glossy; in a little time they were slightly corrugated by the effect of the cold in condensing the enclosed air: the examination was conducted in the open air. Not the slightest difference could be perceived either in the expansion or general appearance of the lungs of the two dogs. Their lungs did not extend by two inches to the inferior part of their respective cavities, and their bulk was insufficient to fill the remaining part of the bags of the pleura. Pray what proof is there that the lungs fill the bags of the pleura? I must confess that I am quite sceptical upon that point, and, on the contrary, believe that in a healthy state they never fill them. To prove that the measure we had recourse to was effectual in preventing the air escaping out of the lungs, when the chest was opened at the conclusion, we divided the windpipe of each below the knots, when they instantaneously collapsed.

Exper. 6.—The description supposes the animal to be standing upright on his hind legs. The right cavity of the chest was transfixed with a sharp-pointed penknife, by thrusting it transversely with a slight degree of obliquity downwards, through the intercostal space, immediately above the upper edge of the eleventh rib, mid-space, between its head and anterior extremity. The animal was afterwards put to death. Dissection: the instrument had pierced the diaphragm, and had slightly wounded the liver; the lung uninjured; the knife had passed as near as possible through the centre of the cavity at that part, and but little short of two inches above its inferior termination. Had the lung extended so low down, it must have been wounded, the knife being sharp-pointed, and pushed in with force.

Exper. 7.—To remove every doubt, with respect to the state of the lung, when deprived entirely of the influence of the auxiliary respiratory organs, the following experiment was made in the open air. The cartilages of all the true ribs were divided, with the exception of the superior one, close to their juncture, with the osseous structure, and the left cavity of the chest laid open its whole length; the diaphragm was punctured; the ribs, and their cartilaginous ends, attached to the sternum were separated and retained asunder, so as to expose and to deprive the lung of every assistance from the auxiliary respiratory organs. The lung rested upon the ribs and side of the vertebræ; on exposure, it shrunk considerably, but did not collapse. Its motion, for it was not at rest, might be compared to that of a leech when it draws up, and again recedes its body, without making any progression; indeed, with both ends fixed, the motion was not

* Edinburgh Medical and Surgical Journal, vol. xiv. p. 647.

that of pulsation, neither was it synchronous with the action of the heart, but it was a slow undulating movement. On closing the gash, and keeping it so for four or five inspirations, then opening it quickly, the lung was found to have increased in volume; on exposure, it again diminished. To close the scene, the knife was plunged into the heart with a determination never to perform another experiment on a living animal, which I had been induced in the present case to do, by my anxiety to solve an important practical problem.

I believe no one has ever appreciated the power of the lungs and their auxiliaries in respiration during life in resisting and diminishing the pressure of the atmosphere, when admitted into the cavities of the thorax through apertures in its parietes. That they do possess a considerable power is beyond a doubt. The oppression of the breathing and the expansion of the lungs are in an inverse ratio to one another, and can be regulated by adjusting the dimensions of the openings into the cavities of the chest. As the apertures increase in their size, the power of expansion of the lungs is diminished, while the oppression of the breathing is augmented, until at last life is extinguished. What quantity of air is sufficient to produce death as long as all the respiratory organs are not restrained, I have not ascertained. The doctrine of the lung collapsing, while the function of the opposite one is unimpaired, on exposure of its external surface to the atmosphere, taught from time immemorial in the schools, I must now consider as erroneous, and feel somewhat surprised that a notion so groundless should have existed for so many ages.

From the foregoing experiments, it appears,

1. That a lung will not collapse from exposure to the atmosphere as long as respiration is carried on by the opposite one, and the auxiliary respiratory powers are not restrained.

2. That a lung possesses for a time, independently of the influence of the diaphragm and intercostal muscles, if respiration is carried on by the opposite lung, a peculiar motive power, the source of which I do not pretend to explain.

3. That a sound lung soon regains its full power of expansion, when the pressure of the exterior air is removed.

4. That air freely and uninterruptedly admitted into both cavities of the chest simultaneously, through tubes of a certain calibre, will not collapse the lungs, if the auxiliary respiratory organs are unrestrained.

5. That air admitted into both the cavities of the chest (of a middle-sized dog) simultaneously through apertures of an inch and better in length in the intercostal spaces, will not collapse the lungs, provided the animal is allowed unconfined the use of his respiratory organs.

6. That a sound lung never fills the bag of the pleura.

If the last physiological inference is correct, it is highly interesting in a pathological point of view. It enables us to explain how hydrops thoracis, or that species of it called hydrops pleurae, may exist to a certain extent, without being attended with any symptoms indicating the presence of the disease, as related by numerous medical authors. We can also more satisfactorily account how the lung so frequently escapes being wounded when weapons penetrate the cavity of the thorax; and how the extravasation which follows, if not considerable, produces but little derangement. It may also have a practical utility, for it informs the surgeon that the lung descends to a certain point only, so that he need not be afraid wounding it should an operation be required below that position.

Dr. Carson retained open the apertures into the chests of his animals with his fingers; whereas mine were kept open in the manner described, which accounts for the different results of our experiments. Dr. Carson, in his Essays, does not allude to this circumstance, but since my investigations he has mentioned it. When air is admitted into the cavities of the chest, the animal requires the aid of all his respiratory powers.

Article VII.

On M. Schweigger's Electromagnetic Multiplier, with an Account of some Experiments made with it. By Prof. Oersted. (Communicated by the Author.)

Immediately after the discovery of electromagnetism, Prof. Schweigger, of Halle, invented an extremely useful instrument for the purpose of discovering very weak electrical currents by means of the magnetic needle. The effect of this multiplier is founded upon the equal action which every part of a conducting wire when it transmits a current exerts upon the magnetic needle. When a part of this wire is curved as in A B C, fig. 1 (Pl. XX), so that the two branches A B and B C are in a vertical plane, and a magnetic needle D E is properly suspended in the same plane, it will be readily conceived that the needle receives an impulse double that which it would receive from one only of the branches. The impulse given by each branch has also the same direction, since it is in fact the same side of the wire which in both branches is opposite the needle. The effect is still further increased when the conducting wire makes several circumvolutions round the needle, as in fig. 2, and thus an elec-

Fig. 1.

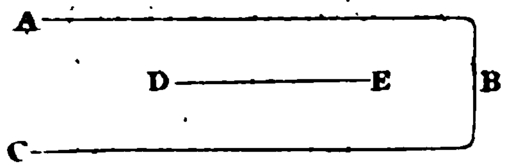


Fig. 2.

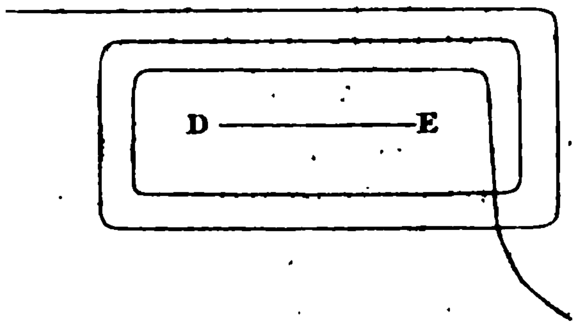


Fig. 3.

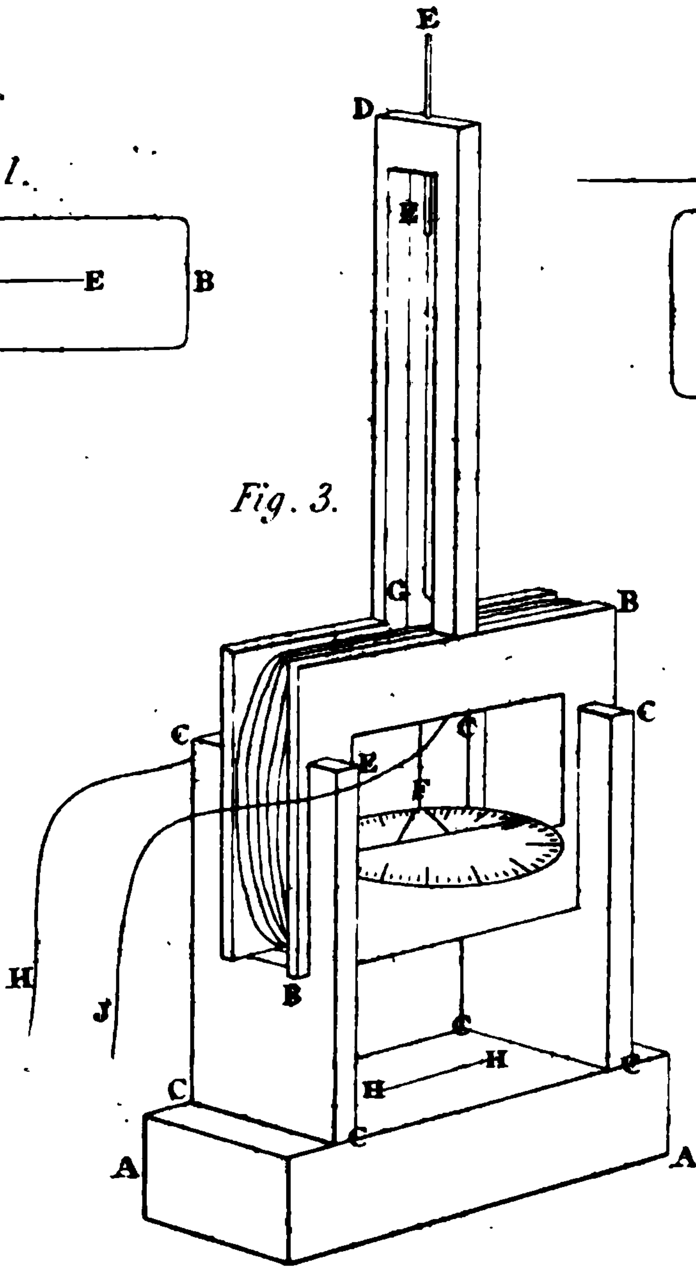


Fig. 4.

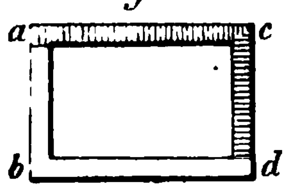


Fig. 5.

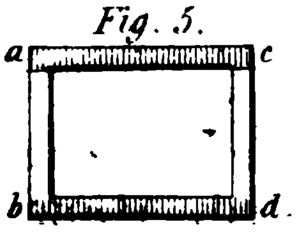


Fig. 8.

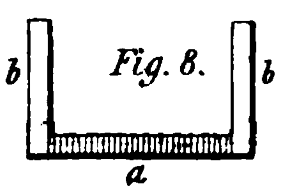


Fig. 6.

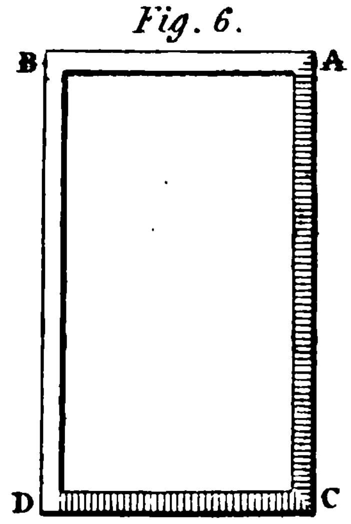


Fig. 7.

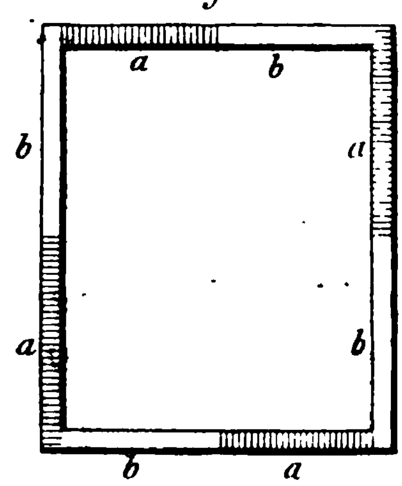


Fig. 10. p. 457.

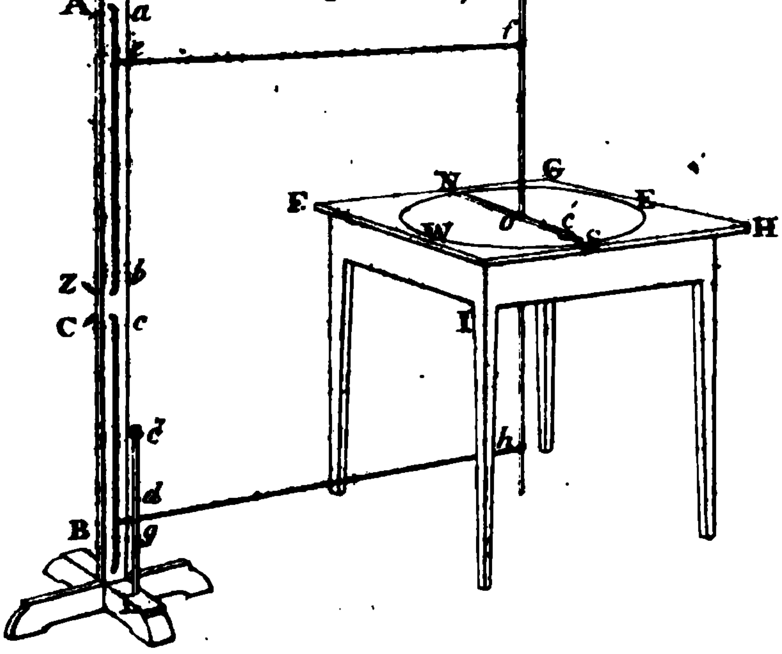
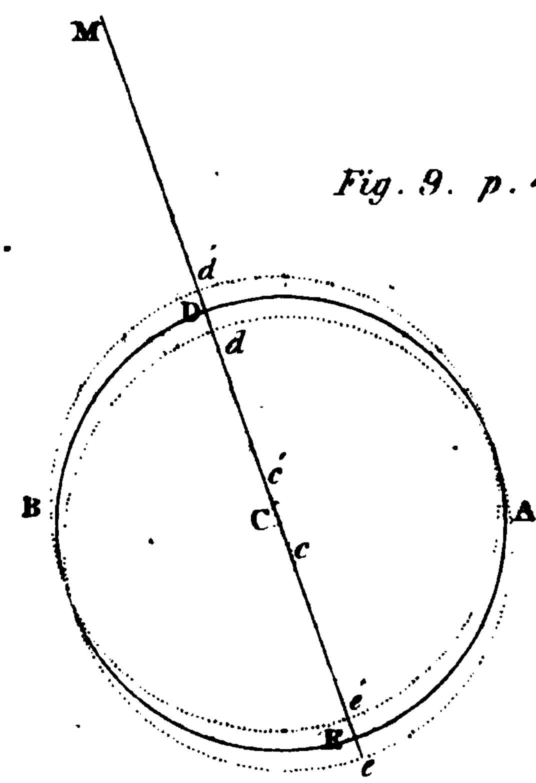


Fig. 9. p. 455.



Engraved for the Annals of Philosophy — for Baldwin, Cradock & Joy June 1. 1823.

tromagnetic multiplier is formed; fig. 3 represents an apparatus according to my construction, which differs, however, from M. Schweigger's in no essential respects. A A, fig. 3, is the foot of the apparatus. C C, C C, are two stands which support a frame B B, which has a groove on the edge to receive the multiplying wire. D D is a stand to support the wire from which the magnetic needle is suspended. E E is a metallic wire passed tightly through a hole made in the upper part of the stand D D. To this metallic wire there is attached by a little wax a thread of raw silk E F, suspending a double triangular loop of paper, in which the magnetic needle is placed. E G is a tube which allows the suspension wire a free passage, and prevents the multiplying wire from touching it. Below the magnetic needle a divided circle is placed to measure the deviations. The multiplying wire is of plated copper, and a quarter of a millimetre, or about $\frac{1}{100}$ of an inch in diameter. It is covered with silk thread, which prevents any communication between the different parts of the multiplying wire; H and J are the two ends of this wire. The use of this apparatus will be understood almost without any explanation. In order to multiply the effect produced by a galvanic arrangement upon the needle, it is requisite only to effect a communication so as to make the multiplying wire a part of the circuit. The effect of a disk of copper and of zinc with pure water as a liquid conductor, was rendered perfectly sensible by this apparatus, and it is even possible by its means to render those galvanic actions sensible, which are too weak to produce a marked effect upon the prepared muscles of a frog. When it is required to discover an action which is so extremely weak as to occasion a scarcely visible deviation, the circuit is interrupted immediately after it has been completed, but it is again effected at each time that the needle is at the point of terminating the preceding oscillation; the apparatus may be rendered still more sensible by putting a small magnetic needle in H H in the situation required to diminish the force with which the suspended needle tends to preserve its direction.

When the multiplier is employed for moderately strong electromagnetic action, thicker conducting wires must be used. If this precaution be neglected, the effect may be diminished instead of increased, owing to the imperfection of the conductor. M. Seebeck has made some very satisfactory researches on this subject, in his memoir on electromagnetism, published two years since in the memoirs of the Berlin Academy.

M. Poggendorf, of Berlin, a distinguished young philosopher, constructed an electromagnetic multiplier very soon after M. Schweigger, and made some striking experiments with it. The experiments of M. Poggendorf having been cited in a work upon electromagnetic phenomena by the celebrated M. Erman, published soon after the discovery of these phenomena, were

known to several philosophers before those of M. Schweigger; which circumstance has given rise to different names for the same apparatus. M. Poggendorf has made a very useful application of this apparatus by employing it for the purpose of examining the order of the conductors in the galvanic series. An account of his labours, is contained in the German Journal, the Isis, for the year 1821. M. Avogadro, in Italy, has used the same plan, but without experimenting on so great a number of different bodies, his memoir contains some other observations which are worthy of being known. By the indications of the electromagnetic multiplier, he discovered that some metals at the first moment of their immersion in concentrated nitric acid, produce an effect contrary to that which is observed in a few seconds afterwards; but this alteration does not occur in dilute nitric acid. The metals which have exhibited this property are lead and bismuth, lead and tin, iron and bismuth, cobalt and antimony. M. Avogadro states, that the first effect which occurs in a concentrated acid is similar to that which happens in a diluted acid, and that it is afterwards that the contrary effect is perceived. I have repeated these experiments with lead and bismuth, and I have confirmed them by other means, excepting only that I have always had at the end of the experiment with concentrated acid, the same effect as that constantly produced by the dilute acid. I have also found that the bars of lead and of bismuth which have been acted upon by concentrated acid, gave in repeated experiments constantly the same effects as by dilute acid, unless fresh surfaces were given to them before they were again immersed in the acid; this renewal of the surfaces may be effected not only by mechanical means, but also by diluted nitric acid. It also frequently happened that the bars which had been in diluted acid, and which had been only slightly wiped, gave at first in the concentrated acid a momentary deviation in the same direction as in the diluted acid, very probably on account of the fluid which remained on their surface; they then gave for some seconds the contrary deviation; that is to say, the same as that observed when the experiment is made with bars well cleaned. At length the deviation became such as it would have been, if diluted acid had been employed as a fluid conductor. It is to be remarked that concentrated nitric acid acts much more strongly upon bismuth than upon lead; and, on the contrary, that the diluted acid acts strongly upon the lead, and scarcely at all upon the bismuth. Thus it follows, that the lead acts as the more positive metal in the dilute acid, but as the negative in the concentrated acid.

It remains only to explain why the deviation produced by the concentrated acid does not continue the same during the whole of the experiment. As I am travelling, I have not time to treat of this, or the analogous experiments related by M. Avogadro thoroughly, but I shall content myself with having contributed

to call the attention of philosophers to this class of experiments which are equally interesting as regards the theory of solution and that of the excitation of the electric current. M. Avogadro mentions also that arsenic acts with respect to antimony as a positive metal in concentrated nitric acid and as a negative in dilute acid. This phenomenon appears interesting in relation to the chemical effect of this acid upon the two metals in its different degrees of concentration.

Among the experiments to which the electromagnetic multiplier gives rise, it may be stated that by its use, we may show, that when two pieces of the same metal are immersed in an acid capable of acting upon them, that which is first immersed acts towards the other as the most positive metal; this experiment is extremely well performed with two bars of zinc and diluted sulphuric or muriatic acid. It would be extremely interesting to examine the electromagnetic changes which take place during every period of the action of acids and alkalies upon the metals, and nothing affords greater facility for this purpose than the electromagnetic multiplier.

Notice read at the Academy of Sciences of some new Thermoelectric Experiments made by M. Le Baron Fourier and M. Oersted.

I have had the honour of exhibiting to this illustrious Academy the remarkable experiments by which M. Seebeck has shown that an electrical current may be produced in a circuit formed of solid conductors only by disturbing the equilibrium of the caloric. We are therefore in possession of a new kind of electric circuits, which may be called thermoelectric circuits, thus distinguishing them from galvanic circuits, which may in future be denominated hydroelectric. On this subject an interesting question arises respecting electromagnetism, and which relates also to the theory of the motion of heat in solid bodies; the question is to examine whether the thermoelectric effects may be increased by the alternate repetition of bars of different matters, and how it will be necessary to proceed to obtain the sum of these effects. It does not appear that the author of the discovery of the thermoelectric circuit has as yet directed his researches to this point. But M. Le Baron Fourier and I agreed to examine this question together experimentally.

The apparatus with which we performed our first experiments is formed of three bars of bismuth, and three other of antimony, alternately soldered together; so that they form an hexagon, and thus constitute a complex thermoelectric circuit, consisting of three elements. The bars are about 4·7 inches long, 0·6 of an inch wide, and nearly 0·16 of an inch thick. We placed this circuit upon two supports, in an horizontal position, taking care to give to one of the sides of the hexagon the direction of the magnetic needle, and we placed a compass as nearly as

possible to and beneath this side. By heating one of the soldered parts with a taper, we produced a very sensible effect upon the needle. By heating two soldered places which were not contiguous, the deviation was considerably increased; lastly, when the temperature was raised at the three alternating solderings, a still greater effect was produced. We also employed an inverse process, reducing by means of melting ice, the temperature of one or more of the solderings of the circuit to the freezing point. It will be readily conceived that in this process the solderings which are not cooled are to be considered as heated with respect to those that are. This manner of making the experiment admits of ascertaining by different processes the requisite comparisons for discovering the laws of the power investigated.

Employing the action of ice and that of flame at the same time; that is to say, by heating the three solderings which were not cooled, we produced a very considerable effect; the deviation amounted to 60 degrees.

We afterwards continued these experiments with a stronger apparatus, composed of 22 bars of bismuth and 22 of antimony, much thicker than those of the hexagon, and we satisfied ourselves that each element contributes towards the total effect. In order to make some other experiments, we interrupted the circuit in one place, and soldered at the extremities of the separated bars, small brass cups which we filled with mercury, in order to have a ready mode of forming a perfect communication between these two points by means of metallic wires. A copper wire nearly four inches long, and 0·04 thick, was nearly sufficient to establish an entire communication; and two similar wires, one by the side of the other, effected a most perfect communication; a similar wire, about 40 inches in length, also effected a pretty good communication, but a platina wire, 0·01968 of an inch in diameter, and nearly 16 inches in length, occasioned so imperfect a communication that the variation amounted to only one degree. A slip of paper moistened with a saturated solution of soda, completely interrupted the communication. There was no chemical action; nor did we observe any sensible ignition as might have been expected in an apparatus capable of producing so great an electromagnetic effect. We may also add, that the sum of the effect of all the elements of the complex electromagnetic circuit, is much less than the sum of the isolated effects, which may be produced by employing the same elements to form simple circuits.

I shall now give a detailed account of the experiments referred to in the above communication, accompanied with some further observations.

The bars which were employed in the following experiments were parallelopipeds, the transverse section of which was square, each side being nearly 0·6 of an inch in length.

Exper. 1.—We formed a rectangular circuit *a b c d*, fig. 4, one-half of which was antimony, and the other of bismuth; *a c d* and *a b d* soldered together, so that the two contiguous were of antimony, and the other two of bismuth. One of the sides was nearly four and a half inches long, and the other three inches; the circuit was placed horizontally upon stands, with two of its sides in the direction of the magnetic needle, and the compass was placed upon one of them. Having left the circuit for a time sufficient to regain the equilibrium of temperature, which might have been disturbed during the placing of it, ice was put upon one of the two solderings, *a* or *d*, which unite the two heterogeneous metals. The compass showed a deviation of 22 or 23 degrees; the temperature of the air was 57° of Fahr.; at a temperature of 68°, the deviation was observed to be 30 degrees. We neglected to note the temperature of the atmosphere at the commencement of the experiment. We shall, therefore, only compare the results of experiments made at the same period.

Exper. 2.—Another circuit, fig. 5, was formed of the same length as the former; but having the opposite sides of the same metal, *a b* and *c d* being bismuth, and *a c* and *b d* of antimony so that the circuit was composed of two thermoelectric elements rendered active by ice placed upon two opposite angles. This circuit produced a deviation of 30 to 31 degrees, under the same circumstances in which the simple circuit produced a deviation of 22 to 23 degrees. The temperature in this circuit has its equilibrium soon restored, so that the thermoelectric effect appears weaker than it would do without this circumstance.

Exper. 3.—A circuit A B C D, fig. 6, the circumference of which was double that used in the first experiment, was put in action by ice placed upon one of the solderings. The deviation was only from 13° to 15°, under the same circumstances which, with the circuit, fig. 4, gave 22 or 23 degrees.

Exper. 4.—Another circuit, fig. 7, was formed, of the same length as the preceding, but it had four alternations, or four thermoelectric elements *a b* (*a* being the antimony, and *b* the bismuth). This circuit was put in action by placing ice upon every other soldering. The deviation of the needle amounted to 31½ degrees, under the same circumstances in which the simple circuit of equal length produced a deviation of only 13 to 15 degrees, but the circuit used in Exper. 2, fig. 5, which had only half its circumference, and half the number of elements, produced nearly the same effect as that obtained in this experiment. Thus it appears, which will be confirmed in the sequel, that the deviations of the needle produced by the thermoelectric circuit increase with the number of the elements when the length of the circuit remains the same, but that they become weaker in proportion as the length is increased. It is also evident, and it will be rendered still more so in the sequel, that these two effects balance each other; so that the effect of a circuit is not

altered, when the length of the circumference increases in the same proportion as the number of the elements; or, in other words, elements of equal length form circuits which produce equal deviations, whatever may be the number of the elements. We confirmed these results by comparing the effects of two, three, four, six, thirteen, and twenty-two elements.

In order to form complex circuits capable of producing a great effect upon the magnetic needle, it will be necessary to employ very short elementary bars; and to avoid the inconvenience which follows from the restoration of the equilibrium of temperature which happens too rapidly in such small circuits, the solderings must be placed alternately in contact with continued sources of heat and cold. There is still another increase of effect in the complex thermoelectric circuit, which is not thus limited by the length of the circumference; but before it is mentioned we shall show the relation which exists between the different elements of the complex circuit.

Exper. 5.—We examined the effects of the circuits by cooling first one, then two, afterwards three, &c. of the solderings which were rendered active; and after several experiments, we found the mean numbers to be as follow: In a circuit of three elements, the first gave a deviation of $15\frac{5}{8}°$; the first two $25\frac{7}{8}°$; the three together 31°. In a circuit of four elements, the ice placed upon one soldering gave a deviation of $13\frac{3}{4}°$; upon two 19°; three 25°; four $31\frac{1}{4}°$. In a circuit of six elements, the first gave a deviation of 9°; the first two $13\frac{1}{4}°$; the first three $18\frac{1}{2}°$; the first four 22°; the first five $25\frac{1}{3}°$; the six together $28\frac{1}{3}°$.

It will be observed that the deviation produced by the first cooled soldering, is nearly represented by double the quotient obtained by dividing the total deviations produced by the circuit, when all its elements are put in activity, by the number of elements plus one. It is also evident that the other numbers nearly approach the value of the simple quotient; but still they appear to form a decreasing series. We are now alluding to the deviations measured by the angles, and not of the real extent of the effects. If it were not necessary to regard the different distances of all the points which act upon each other in the different positions of the needle, and even to consider what may be the reciprocal situation more or less oblique of the edges of the conductor and of the needle, the effects might be represented by the tangents of the deviations. It is, however, remarkable, that the experiments which we have made indicate a constant relation between the deviations. If such experiments as we have hitherto had an opportunity of performing were susceptible of greater exactness, consequences interesting to the theory would undoubtedly arise from them.

Exper. 6.—Thermoelectric action may be rendered sensible by means of the electromagnetic multiplier. In order to produce

this effect, one of the two pieces of metal, *a*, fig. 8, is combined with two pieces of *b*, the other, so that this arrangement constitutes a broken circuit, the two ends of which are of the same metal. After having put some ice upon one of the solderings, a communication is established between the two pieces *b* by means of the multiplying wire.

The effect of this is sensible upon the needle of the instrument, but yet it is very weak; weaker, for example, than the effect of a piece of copper and silver with water as a fluid conductor. The effect is rendered more evident by communicating a fresh impulse to the needle, at the end of each return after a former impulse.

The extraordinary weakness of this action is very remarkable. We learn from this result that the same thermoelectric elements which produce a great effect upon the magnetic needle of the compass, when their communication is made by a short and thick conductor, act but very little even upon a much more sensible needle, when the communication is made by a thin conductor of considerable length. A hydroelectric current excited by a piece of zinc and silver, with water as a fluid conductor, produces an effect upon the needle perhaps a hundred times greater than that of the thermoelectric current; nevertheless the effect produced by the former upon the needle of the compass, even when the communication is made between the elements by the best conductors is scarcely sensible; while the effect of the latter upon the compass is not only sensible but considerable. All this marks a very important property of the thermoelectric current, which indeed might have been foreseen by theory, but which experience should confirm; that is to say, the thermoelectric circuit contains the electric powers in much greater quantity than the hydroelectric circuit of equal size; but, on the other hand, the intensity of force in the former is much weaker than in the latter. Since the first electromagnetic experiments, it has been clearly seen that the deviation of the needle produced by the electrical current would be regulated according to the quantity of electric power, and not by its intensity. Thus the considerable deviation which the thermoelectric current produces is an indication of the great quantity of power which it contains. As to the intensity, it is universally acknowledged, that an electric current pervades conductors so much the more readily as it is more intense: the hydroelectric current which more easily pervades the wire of the multiplier than the thermoelectric current does, must, therefore, be more intense. The much greater quantity of electric power which must be admitted to exist in the thermoelectric current, will form no objection to this reasoning; for it is perfectly evident that in the case in which a current A, of intensity equal to that of another current B, but greater in quantity, is presented to a conductor sufficient to transmit the quantity of B only; this

conductor must be capable of transmitting a part of the current A, equal to the current B; and if we suppose A to possess a stronger intensity than B, the transmission of the former will be still greater.

Exper. 7.—We tried the effect of the complex circuit upon the needle of the multiplier, and we found it considerably augmented, by increasing the number of the elements of the circuit, even in cases in which the number did not increase the effect upon the compass. We obtained this result by experiments with 6, 13, and 22 elements. It appears then that the intensity of the power increases in the circuit with the number of the elements, which is perfectly conformable to what happens in Volta's pile. The circuit had no sensible effect upon the compass when the communication was made by the multiplying wire.

Exper. 8.—A platina wire, about 0·004 of an inch in diameter, was not ignited by a thermoelectric circuit composed of 13 elements, but which was nevertheless capable of causing the compass to deviate 28 degrees; yet a hydroelectric circuit producing an equal effect upon the compass, was quite sufficient to ignite the same wire. This difference is derived from the too weak transmission of the thermoelectric current by the platina wire. During the communication effected by this wire, the needle of the compass indicated only 2 or 3 degrees of deviation. An iron wire, about 0·008 of an inch in diameter, was not ignited. The communication effected by this wire produced a greater deviation than the platina wire, but only by 5 degrees. We must wait for the current produced by a thermoelectric apparatus composed of several hundred elements, before we shall be able to ignite a metallic wire.

Exper. 9.—We were unable to produce any sensible chemical action by the thermoelectric circuit; those fluids which have the greatest conducting power resisted its action; for instance, nitric acid, solution of soda, and many metallic solutions. We shall mention only one of these experiments, which, frequently repeated, appeared to produce some chemical effect. We placed a piece of blotting paper moistened with solution of sulphate of copper between two perfectly new five franc pieces; the precaution was taken to put the two pieces in contact with the paper on the sides which had similar impressions, and the thermoelectric current was passed through the two pieces of metal and the moistened paper. In a quarter of an hour some parts of the silver were slightly covered with copper. But as this trace of metallic precipitation did not resist washing accompanied with slight friction, we are disposed to consider this experiment as too questionable. During the time that the two pieces of silver with the paper formed part of the circuit, not the slightest effect was produced upon the compass, so that this small piece of moistened paper may be said to have

entirely interrupted the thermoelectric current. In a state of such perfect isolation, no sensible chemical effect could be expected. From the slight intensity indicated by the multiplier, there is reason to think that it would require an electric circuit of many hundred elements to pervade a fluid equally well as a Volta's pile formed of four or five elements; but it is very probable that such an apparatus will produce effects similar to those which may be expected from hydroelectric piles, the metallic elements of which are enormously large.

Exper. 10.—The action of electrical currents upon animal bodies is one of the most remarkable which it exerts. The thermoelectric circuit excited no sensible taste, when it was made to act upon the tongue; but upon a prepared frog, it produced effects of two slightly different metals; this result evinced that the nerves of a frog are excellent conductors.

Exper. 11.—A thermoelectric circuit of 13 elements produced no effect upon the most delicate electrometers; nor did Volta's condenser unequivocally indicate signs of electricity in this circuit. But we acknowledge that we did not repeat this experiment so often as it deserves.

Exper. 12.—The experiments which we have related are sufficient to prove how weak the thermoelectric current is with relation to the conducting power even of the best conductors. Another experiment produced similar results under other forms. The great circuit consisting of a rectangle, the length of which was nearly four times its width, was placed in such a manner that the two short sides were parallel to the needle of the compass; the compass was placed on one of these sides, and the two adjacent elements were rendered active. After having observed the deviation of the needle, a communication was effected between the active parts furthest from the compass by means of a copper wire, so that all the active parts might form a separate circuit. After this diminution of the circumference of the circuit, the needle indicated a stronger action; this effect would not have been very evident, if the transmission of the thermoelectric current were not so difficult even in the metal, that a difference of passage of two or three feet could produce so considerable a change in the effect. It must be observed that the same copper wire employed to effect the communication, when some part of the whole circuit was interrupted, would produce scarcely the same effect as the immediate junction. When the part of the circuit furthest from the compass was rendered active, and a similar communication was effected, the deviation of the needle diminished. However, this difficulty of transmission is unattended with any thing that ought to occasion surprise. For the electricity in a circuit of conductors, in consequence of their contact, must flow in proportion as it acquires the intensity requisite to clear the passage in these conductors; therefore this electricity never acquires sufficient intensity to

pervade the conductor with facility, but it will constitute a current as soon as the circuit does not oppose the obstacle of very considerable isolation. It is easy to perceive that the quantity of electricity developed by this continual excitation which exists in the circuit, ought to be so much the greater as the circuit is a more perfect conductor. Thus the thermoelectric circuit supplies an incomparably greater quantity of electricity than any other circuit which has as yet been invented. If by other circuits water, the acids, and the alkalies, have been successively decomposed, it is not beyond the limits of probability, that by means of a new circuit, we shall be able to decompose even the metals; and thus complete that great change in chemistry which commenced with the pile of Volta.

Article VIII.

Analysis of the Native Sulphate of Iron and Alumina. By R. Phillips, FRS. L. and E. &c.

Until after I had completed the analysis of this substance, I was not aware that it had been noticed in any work on mineralogy: I find, however, that it has been described in the 24th number, p. 97, of Mr. Sowerby's Exotic Mineralogy; the specimen mentioned and figured in this work under the name of sulphate of iron and argilla, is stated to be from Bacherstolln, in Schmolnir. Mr. Sowerby mentions that it seems to have been mistaken for native alum, but he justly observes that it differs from alum in containing no alkali, and that the solution yields it upon the addition of potash.

The salt which I subjected to examination originates from the decomposition of iron pyrites in slate-clay. It was presented to me by Charles Macintosh, Esq. and is plentifully met with in the slate clay of the deserted coal mines of Hurlet and Campsie, which as well known is employed for the double purpose of preparing alum and sulphate of iron.

The sulphate of iron and alumina exists in the state of soft delicate fibres, easily separable from each other; it is colourless, and its lustre is silky, and it resembles asbestus in appearance. It is so extremely light that 100 grains of the crystals occupy a space equal to that of an ounce and a quarter of water. By exposure to moist air, the iron is converted into peroxide, and the crystals become yellowish-brown. It is readily soluble in water, and the solution, as above stated, readily yields crystals of alum on the addition of the salts of potash or ammonia. By spontaneous evaporation, crystals of common sulphate of iron are obtained, and the sulphate of alumina remains in solution; this

circumstance renders it probable that the salt in question is not producible artificially; but this I have not tried. Crystals of common sulphate of iron are sometimes mixed with it. When the usual tests of the presence of iron are added to the solution, the common evidence of the existence of that metal is obtained; prussiate of potash gives a very light blue precipitate, showing that the iron is principally in the state of protoxide.

One hundred grains of this double salt, cleared as much as possible from the small fragments of slate-clay, were dissolved in distilled water; the solution was filtered, and four grains of earthy matter remaining undissolved, the deficiency was supplied by an equal quantity of the pure salt. The solution was heated with a little nitric acid to convert the iron into peroxide, and nitrate of barytes was added to it as long as precipitation ensued; the sulphate of barytes washed and dried amounted to 91·25 grains, which are equivalent to 30·9 of sulphuric acid. The slight excess of nitrate of barytes being removed from the solution by means of sulphuric acid, the solution was decomposed by ammonia added in excess, and the peroxide of iron and the alumina were of course precipitated together.

The ammoniacal solution was examined in order to discover whether any minute portion of lime or magnesia was contained in the salt, but none was detected; the precipitate was boiled with a solution of soda to separate and dissolve the alumina, and the peroxide of iron left being washed, dried, and ignited, weighed 23 grains; but the iron exists in the state of protoxide; and as 40 of peroxide consist of 36 protoxide and 4 oxygen, 23 are equivalent to 20·7 of protoxide, which is of course the quantity contained in 100 grains of this double salt.

The alkaline solution which contained the alumina was supersaturated with muriatic acid, and the alumina precipitated by carbonate of soda. When washed and ignited, it weighed 5·2 grains.

I made an attempt to ascertain the quantity of water of crystallization by direct means, but it failed; indeed the nature of the salt is such as to render it scarcely practicable; for it is, I think, more than questionable, whether anhydrous sulphate of iron or of alumina can exist; and, at any rate, there is great danger either of not expelling the whole of the water by heat, or of driving off some of the acid with it.

From the experiments above stated, it appears that this salt consists of

Sulphuric acid	30·9
Protoxide of iron	20·7
Alumina	5·2
Leaving for water	43·2
	100·0

I repeated these experiments with a fresh quantity of the salt, and the results agreed almost precisely with respect to the sulphuric acid and oxide of iron, but there was rather less alumina: the difference was not, however, sufficient to induce me again to repeat the analysis.

I have stated on a former occasion my reasons for believing, that hydrogen = 1, alumina is 27; and this determination is strengthened by the results of Sir H. Davy's experiments stated in p. 357 of his Elements, and to which I have only lately particularly adverted. He says that from experiments which he "made on the quantity of ammonia required to decompose saturated solutions of alumina in acids, it would appear that the number representing alumina is about 48, and supposing it to consist of one proportion of aluminum, and one of oxygen, 33 will be the number representing aluminum." If, however, the atom of oxygen be represented by 8 instead of 15, then the number for alumina will be, according to Sir H. Davy's experiments, 25·6; now this sufficiently approaches 27 to assist in deciding the question whether alumina should be represented by 27, or by 18, which latter number Dr. Thomson considers to be the weight of its atom.

Representing then sulphuric acid by 40, protoxide of iron by 36, alumina by 27, and water by 9, it will appear that the sulphate of iron and alumina in question is composed of

4 atoms of sulphuric acid..	40 × 4 =	160
3 atoms of protoxide of iron	36 × 3 =	108
1 atom of alumina.	=	27
25 atoms of water.	9 × 25 =	225
		520

We may then consider the salt as composed of

3 atoms of sulphate of iron.	76 × 3 =	228
1 atom of sulphate of alumina.	=	67
25 atoms of water.	=	225
Weight of the atom.		520

On this view of the subject, the theoretic composition of the salt will be as follows, which, it will be observed, agrees very nearly with the analysis:

Sulphuric acid	30·76
Protoxide of iron	20·76
Alumina.	5·19
Water.	43·26
Loss	0·03
	100·00

Or,

Sulphate of iron	43·84
Sulphate of alumina	12·88
Water	43·28
	100·00

Article IX.

On the Crystalline Forms of Artificial Salts. By H. J. Brooke, Esq. FRS.

(To the Editor of the *Annals of Philosophy.*)

DEAR SIR,

The introductory volume to the Science of Crystallography on which I have been for several months engaged, having passed through the press, I propose now to resume an examination of the crystalline forms of the artificial salts, a subject which has been hitherto much neglected, and of which, during the last two years, we have frequently spoken.

As an evidence of the neglect with which the crystallographical characters of the productions of the laboratory have been treated, I may refer to the recent edition of Dr. Henry's Chemistry; and I do this, not to impeach in the slightest degree the value of that work, but merely to remark, that instances of imperfect and useless descriptions of crystalline forms are admitted into volumes otherwise of great worth.

The crystalline characters of the artificial salts will, if strictly attended to, frequently assist the researches of the chemist.

An examination of the forms, and measurements of the angles of the crystalline deposits from his experimental processes, will immediately inform him whether his experiments have produced such results as he had anticipated, or whether his compounds are new and unexpected. For this purpose, however, the reflective goniometer must be added to his other implements, and he will not fail soon to discover its value in reference to his pursuits.

But to be provided with the means of effectually applying this instrument, he must be acquainted with the forms, and the measurements of the angles of all the known crystals of those salts. During the last summer, I measured a considerable number of these, most of which I have to thank you for procuring for me, and for some others I am indebted to the kindness of Mr. Teschemacher. Several I also prepared myself; and I shall still feel obliged to you, or to any of your friends, for measurable crystals of any of these artificial compounds.

With a view to render the descriptions of these as simple and as practical as possible, it is not my intention to consider them mathematically, and in relation to the theory of decrements. The information the chemist requires to be possessed of concerning the crystals which may be formed during his operations, is the character of their simplest or primary forms;* their cleavages where they can be given; their modified or secondary forms; the angles at which their planes severally incline to each other; with occasional notices on their predominating characters, and on any peculiar habitudes which may be observed to belong to particular crystals.

Descriptions of several of the artificial salts, founded on these characters, will form the substance of this and some following communications. These will be accompanied by figures which are not drawn with geometrical truth, and are intended merely as diagrams to which the measurements of the crystals may be more conveniently referred, and which will, at the same time, convey a general idea of the form of the substance described.

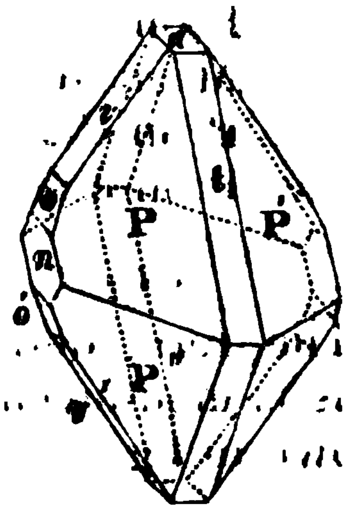
Crystals deposited from the Oil of Cubebs.

Of the chemical nature of the substance of these crystals, which I received from Mr. Teschemacher, I know nothing.

The predominating form of the crystals is that of an octahedron with a rhombic base, as shown in fig. 1, measuring as follows:

P on P′ about	115°	45′
P over plane v	74	56
P on P″	145	40
n on o	165	0
n on v	151	0
n on a	90	0

Fig. 1.



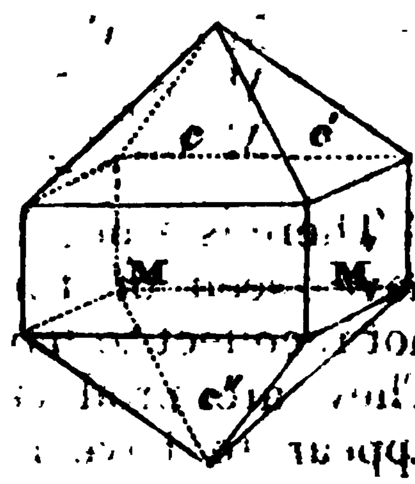
Arseniate of Potash.

The primary form of this substance may be regarded as a right square prism.

In the crystals I have measured, the terminal edges of the prism are replaced, as seen in fig. 2, measuring as follows:

M on c / M′ on $c′$ }	133°	15′
c on $c′$	122	2

Fig. 2.

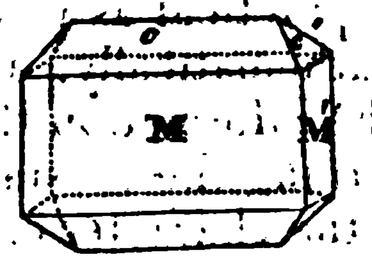


The predominating form of most of the

* The nomenclature of forms, and the letters placed on the crystals, are those which are used in the introductory volume already alluded to.

crystals I have seen is exhibited in fig. 3, where the plane M′ is so much less than M as to confer on the crystal an appearance of the base being rectangular, but not square; thus affording one of the numerous instances which will be found among crystals, of deviation from regularity and symmetry in their natural forms, by a disproportionate extension of some of their planes, a character which would frequently lead to an inaccurate determination of their forms, if the goniometer were not resorted to. But the goniometer will generally correct the erroneous conclusion derived from the appearance of the crystal; as it has done in this instance, by showing that M on *c*, and M′ on *c*′, measure alike, which it is highly improbable they should do if the base of the prism were not square.

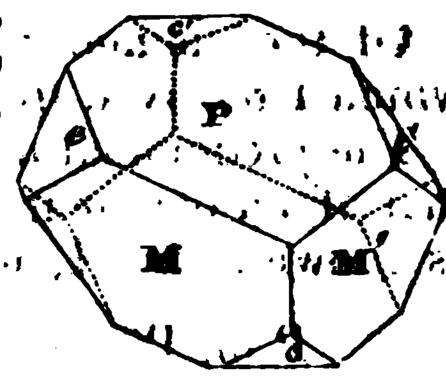
Fig. 3.



Chlorate of Potash.

The primary form is an oblique rhombic prism, some of the crystals being modified as in fig. 4. The cleavage is easy parallel to the planes M and M′, and the cleavage planes are brilliant, but the only crystals I have are too thin to obtain a cleavage plane parallel to P. The measurements are as follows:

Fig. 4.

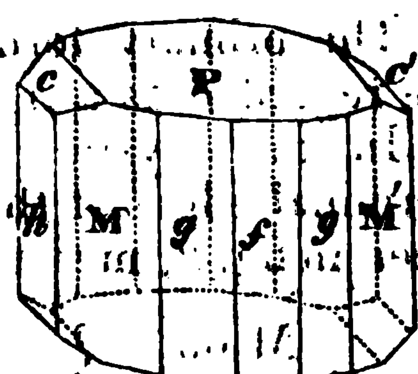


P on M, or M′	105°	30′	
M on M′	104	0	
P on *c*′	106	45	dull
P on *e*, or *e*′	129	45	

Tartrate of Potash and Soda.—Rochelle Salt.

The form derived from cleavage is a right rhombic prism. This is modified in the crystals measured, as shown in fig. 5.

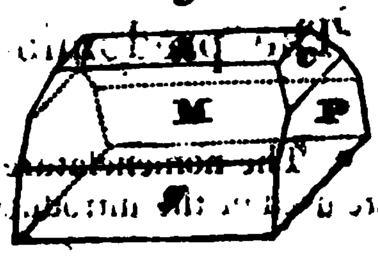
Fig. 5.



P on M, or M′	90°	0′
P on *c**	138	50
M on M′	100	0
M on *g* / M′ on *g*′	163	0

There is a peculiarity in all the crystals I have seen of this substance which I do not recollect to have observed in any others. They are produced nearly in halves, and appear to have rested or been formed on planes which would have passed through the middle of the entire crystal. One of these natural segments is shown in fig. 6. In

Fig. 6.



* *c* is a dull plane, and occurs on only one of the crystals out of several that I have seen.

some of these, the front half of fig. 5 is the portion produced; the plane *f* being then uppermost. In some of the segments, however, there is a slight deviation from this exactness of position of the planes *f* or *h*.

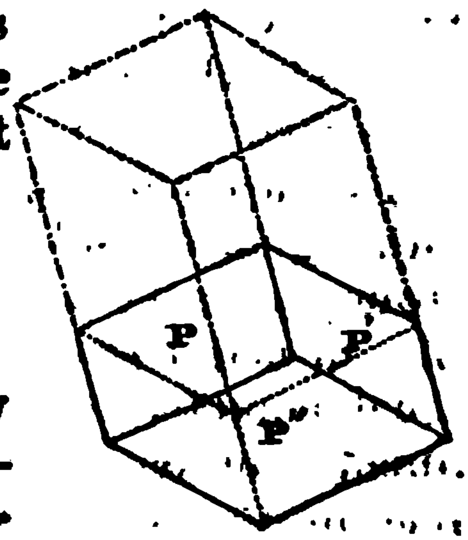
Nitrate of Soda.

The primary form is an obtuse rhomboid.

P on P′	106° 30′
P on P″	73 30

and there are not any modifications on the crystals measured. Some of these are lengthened into apparently oblique rhombic prisms, as shown by the produced dotted lines in fig. 7, but this disproportionate extension of some of the primary planes has been already stated not to be unfrequent among crystals.

Fig. 7



I am, dear Sir, yours truly,

H. J. Brooke.

I have just learned that Mr. Levy has very recently taken up this subject, and has measured and determined with a view to publication, the forms of many of the artificial crystals, without being aware of my having previously occupied myself in a similar manner. He has proceeded mathematically, and will probably still give his results to the public; and there can be no doubt that he will confer an additional interest on the inquiry.

Article X.

Astronomical Observations, 1823.
By Col. Beaufoy, FRS.

Bushey Heath, near Stanmore.

Latitude 51° 37′ 44·3″ North. Longitude West in time 1′ 20·93″.

April 29. Emersion of Jupiter's first satellite	8h	19′	43″	Mean Time at Bushey.
	8	21	04	Mean Time at Greenwich.
May 6. Emersion of Jupiter's second satellite	8	26	32	Mean Time at Bushey.
	8	27	53	Mean Time at Greenwich.

Article XI.

Analyses of Books.

An Essay on Magnetic Attractions, and on the Laws of Terrestrial and Electro-Magnetism, &c. By Peter Barlow, Associate in the Society of Civil Engineers, and of the Royal Military Academy. *Second Edition, much enlarged and improved.*

We have to apologise to Prof. Barlow, and to our readers, for our tardiness in noticing this much improved edition of his work; but we shall now endeavour to compensate for the delay, by giving a more complete account of it than various circumstances, which it is unnecessary to particularize, would have permitted us to have done at an earlier period.

The leading object of this edition, as of the former one, although a considerable portion of the work is devoted to electromagnetism, is the developement of the mathematical principles of magnetism, and their application to the correction of the local attraction of vessels, "which is of more and more importance," the author remarks, in the preface, "as every year is leading to some new application of iron in the construction and equipment of ships of war, and which, if persevered in without some mode of correction, would soon render the compass worse than useless as a nautical instrument."

"It may be observed, for example," he continues, "that besides there being at present considerably more iron ballast than formerly, the water-casks are now replaced by iron tanks presenting an immense attracting surface; iron knees, sleepers, plates, and, in some cases, the riders, have been introduced in lieu of those of timber; even the hempen cables have been put *hors de service* by the patent cables of iron,—gun-carriages of this metal are at this moment supplanting those of the usual material: the ingenious patent capstan of Captain Phillips, which will doubtless soon become generally applied, is principally of iron; and, although of no considerable mass, is so situated as to affect the compass very sensibly; and, lastly, it seems probable that even the masts are to be attempted in this material."

The work is now divided into three parts; the first containing the greater portion of the matter constituting the former edition, of which some account was given in the *Annals*, O. S. vol. xvi. p. 294—307, with the addition of some experiments on the local attraction of vessels, which, by the favour of the Lords of the Admiralty, the author has been enabled to make on board several of his Majesty's vessels, and of the results on the same subject obtained by a series of observations in his Majesty's ship Leven, during a voyage to, and survey of, the western coast of Africa. Prof. Barlow has also appended to this divi-

sion of the work, his papers, "*On the Effects produced in the Rates of Chronometers by the Proximity of Masses of Iron*;" and "*On the anomalous magnetic Action of hot Iron between the bright and blood-red Heat*," first published in the Phil. Trans. for 1821 and 1822; and already noticed in the *Annals*.

After describing the additional experiments and observations on the local attraction, which fully confirm his former conclusions, Mr. B. concludes the consideration of that subject in the following manner:

"Such is the present state of this method of correcting the local attraction of vessels; and here I must take my leave of the subject, on which I have already bestowed much time, and have incurred some pecuniary charge in carrying the experiments into execution. I have, I trust, shown very clearly by the results reported in the preceding part of this section, particularly in those of the Barracouta, that the errors arising from the local attraction are of such a nature and amount, as to require correction. I have also explained a simple method by which this is proposed to be effected; and I have given testimonials of its efficacy, in a case where it was submitted to trial during a voyage of sixteen months."

The second part of this Essay contains "*A Theoretical Investigation of the Laws of Induced and Terrestrial Magnetism*;" consisting of the following sections: "I. Investigation of the laws of magnetism peculiar to iron bodies—Of the horizontal needle—Of the dipping needle—General results. II. On the change of magnetic intensity of a needle as affected by iron spheres. III. On the magnetic action of bars of iron—Supplementary experiments on the action of iron plates. IV. Application of the preceding formulæ to the magnetism of the terrestrial sphere. V. On the situation of the terrestrial magnetic axis, and on its annual motion."

Mr. Barlow founds the investigation in the first section upon the following hypothesis, which is a modification of that proposed by Mr. Bonnycastle in the Philosophical Magazine, vol. lv. p. 132, 446.

"1. Magnetic phenomena are due to the existence of two fluids in a greater or less degree of combination, and such, that the particles of the same fluid repel, and those of an opposite nature attract, each other.

"2. These fluids in iron bodies exist naturally in a state of combination and equilibrium, till that state is disturbed by some exciting cause.

"3. But if a body, already magnetic, i. e. one in which these fluids are held in a state of separation, be brought within the vicinity of a mass of iron, such as is supposed above, the concentrated action of each fluid in the magnetized body will act upon the latent fluids in the quiescent body, by repelling those of the same, and attracting those of the contrary kind, and thus impress upon the latter a temporary state of magnetic action; which will

remain only while the two bodies maintain their respective situations.

"4. The quantity of action thus impressed upon the iron body will depend, *first*, upon the intensity of the exciting magnet; *secondly*, upon the capacity of the quiescent body for magnetism, or the quantity of these fluids contained in it; and, *thirdly*, upon the cohesive power of the iron, which latter quality determines the depth to which the exciting magnet is able to disengage the two fluids.

"The above embraces every case; viz. of any magnet, natural or artificial, developing the magnetism in any given iron body; but in that to which our attention will be principally directed, namely, the displacement occasioned by the magnetic action of the earth on spheres of iron, we shall find more limited in its results, and more susceptible of correct mathematical investigation.

"5. In this case, for instance, we may suppose the action to take place on every particle of the mass in lines parallel to each other, and corresponding with the direction of the dipping needle; also that every particle is at the same distance from the centre of the disturbing force, and consequently that the displacement in each particle is equal also; conditions which throw great facilities into the analytical investigation of the laws of action.

"6. For the sake of illustration, let A B C D, fig. 9 (Pl. XX), represent a sphere of iron in its non-magnetic, or quiescent state, and let C M be the line in which the terrestrial magnetism is exerted from a centre of action, M, which is at such a distance that the diameter of the sphere is inconsiderable in comparison with it; then every particle on its surface, and to a certain distance within it, will be acted upon by equal powers, and in directions parallel to each other; whereby the fluids in the quiescent body, before in a state of combination, will be separated in each particle; and the two fluids may now, therefore, be conceived to form two spherical shells, A *e* B *d*, A *e′* B *d′*, whose centre of action will be in *c*, *c′*, their distance from each other being greater or less, according to the circumstances stated in No. 4.

"7. Therefore, in computing the action of such a mass of iron in its temporary state of magnetism upon a distant particle of magnetic fluid, we may refer it to those centres; we shall also assume, that the law of action in this, as in all other cases of central action, is inversely as the square of the distance."

The limits to which we are necessarily restricted will not allow us to proceed with our author to the mathematical deduction from the foregoing hypothesis of the laws which he had previously drawn from experiment; nor to his computations respecting the horizontal and dipping needles; suffice it to say, that the approximative agreement of their results with actual observation, is of a very satisfactory nature. We are likewise compelled to pass over the second, third, and fourth sections,

From the calculations in the fifth section, it appears, that, according to the hypothesis, "the dip has not an uniform increase, but is changing now more rapidly than it has ever before done since magnetical observations have been made. Its decrease during the last five years has been nearly half a degree; and if our principles be correct," Mr. Barlow continues, "it ought to decrease nearly the same during the next five years; a short time, therefore, will either confirm or refute the hypothesis on which we have founded the preceding computations. Agreeably to which we ought to find in

1828 the variation	24°	29′	dip	69°	43′	
1833	24	26	..	69	21	

"The dip, therefore, is at present changing more rapidly than the variation; and it will continue to decrease with the latter for about 260 years, when the longitude of the magnetic pole will be 180°; the variation will, therefore, then be nothing, and the dip only 56°, which will be its minimum; they will then both increase together for the next 260 years, when the needle will have its greatest easterly variation, and will then again return towards the north, the variation decreasing, but the dip still increasing, for 165 years longer; viz. till about the year 2510, when the magnetic pole will be again on the meridian of London; the variation will be zero, and the dip being then at its maximum will amount to 77° 43′."

PART III.—*On Electromagnetism.*

This portion of Mr. Barlow's work consists of three sections, the first being a sketch of the present state of the science, in which, after mentioning the long known facts respecting the magnetic agency of lightning, and the early experiments of Ritter, he concisely describes the late researches and experiments of Prof. Oersted, M. Ampere, M. Arago, Sir H. Davy, and Mr. Faraday. The second section relates to the mathematical laws of electromagnetism. "In the preceding parts of this work," the author observes, "I have attempted to reduce the laws of induced magnetism to mathematical principles; and as soon as I heard of M. Oersted's discovery, I was desirous to establish, on similar principles, the law of electromagnetism; but it was some time before I was able to construct an apparatus convenient for the purpose. Having, however, at length effected this necessary preliminary to my satisfaction, I proceeded to make the course of experiments, and to undertake the investigations which form the subject of the present section."

"My first object was to repeat very carefully all the experiments of M. Oersted, MM. Ampere and Arago, of Sir H. Davy, and Mr. Faraday, with some others suggested by the results thus obtained; and having attentively considered all the peculiarities of action thus developed, I was led to consider that all the apparently anomalous effects produced on a magnetised

needle by the action of a galvanic wire, might be explained by the admission of one simple principle; viz. *that every particle of the galvanic fluid in the conducting wire acts on every particle of the magnetic fluid in a magnetized needle, with a force varying inversely as the square of the distance; but that the action of the particles of the fluid in the wire is neither to attract nor to repel either poles of a magnetic particle, but a tangential force which has a tendency to place the poles of either fluids at right angles to those of the other; whereby a magnetic particle, supposing it under the influence of the wire only, would always place itself at right angles to the line let fall from it perpendicular to the wire, and to the direction of the wire itself at that point.*"

"I pretend not to illustrate the mechanical principles by which such an action can be produced; I propose only to show, that if such a force be admitted, all the results obtained from the reciprocal action of a galvanic wire and a magnetized needle may not only be explained, but computed, and that the results agree numerically with experiments."

The galvanic instrument employed by Mr. Barlow, differs from Dr. Hare's calorimotor merely in the mechanical contrivance for lowering it into and raising it out of the fluid; "that part of the apparatus which peculiarly appertains to the experiments I am about to detail," he says, "is represented in fig. 10. A B is an upright stand, placed near the poles of the battery; *a b*, *c d*, are two staples of stout copper wire, driven into the upright, the two ends at *b* and *c* passing quite through, as shown at C and Z; and on which two wires are fastened by spiral turns, and with which the communication is made with the poles of the battery; *e f*, *g h*, are two copper wires of the same dimension as the staples, each four feet long, having their ends flattened and drilled so as just to enable them to slide freely upon the wires *a b*, *c d*, and the vertical wire *f h*, also four feet in length, which passes through a hole in the top of the table F G H I, and so tight as to render it perfectly fixed. On the plane of the table, which is two feet in square, the circle N E S W is described about the centre *o*, and divided into the points of the compass and smaller divisions; N S is an index or box ruler, through which the wire *f h* passes, so that the former may be turned freely about the latter, and set to any proposed azimuth. On this ruler is placed the small compass *c'*, by means of which the deviation at any given time may be taken; *c''* is another compass placed on the top of the support L *c''*, and is intended to remain fixed in its place, in order to serve as a standard for estimating and comparing the power of the battery at different times."

"For the principal experiments, this apparatus is placed so that the plane of the rectangle of wires is perpendicular to the magnetic meridian; because in this position the horizontal wires being east and west, they have no effect in deflecting the

needle from its direction (at least there is only one exception to this; which will be noticed hereafter), and consequently all the effect produced upon the needle during the rotation of the index in the circle N E S W, is due to the vertical wire only, except so far as the horizontal wires may increase or diminish the directive power of the needle. This, however, in the cases to which we shall refer, is very inconsiderable."

"But in order that we may know precisely what part of the change of deviation between one situation of the compass and another, is actually due to that change of position, recourse must be had to the standard compass, which, always remaining fixed in its position, may be used as a constant indicator of the strength of the battery. But as the application of this measure to computation is involved in principles not at present explained, it will be proper first to inform the reader of the means which I employ in the first instance to preserve an uniformity of action during every separate course of experiments. These were as follow:—

"The vessel which contains the dilute acid, into which the plates are immersed, holds nearly 20 gallons; and I begin the experiments with little more than 12 gallons; moreover the plates are not, in the first instance, let down to their lowest point. The intensity shown by the standard compass after the connexion has been made some minutes, is noted; and by breaking off and making the contact anew, this same intensity occurs again, the power being always strongest when the contact is first made; then when the standard compass returns to its former bearing, the observation with the other compass is taken; the contact broken and renewed, and so on as long as the battery retains sufficient power. When this fails, the plates are lowered a little more; the power thus increased, and the observations resumed, till at length the plates being wholly down, and the power too weak, recourse is had to a supply of more dilute acid; by which means a tolerably steady action is kept up longer than is necessary for any series of experiments of this kind. It will be observed here, that in this case the only use made of the standard compass is to indicate the *same intensity of action*, and consequently involves no theoretical principle that will be objected to by the most scrupulous theorist or observer, but it will be seen in subsequent articles that this indicator is susceptible of a more extensive application."

Prof. Barlow having thus described his method of experimenting, now proceeds to explain the principles of computation, and to compare the numerical results thus obtained, with those derived from experiments.

"According to the hypothesis, if we conceive the wire in the first instance to be vertical, and the compass placed to the north or south of it, and opposite its middle point, the centre of action will lie in the horizontal plane, and at right angles to the

natural horizontal direction of the needle. The latter, therefore (which, for simplicity sake, we shall at present consider as indefinitely short with regard to the distance), will, at either of these points, be acted upon by two rectangular forces; viz. the galvanic force in an east and west direction, and which we may denote by f, and the natural magnetic or directive force m; consequently, according to the principle of forces, the resultant will be expressed by $\sqrt{(f^2 + m^2)}$ and the angle which it makes with the natural direction of the needle, being called Δ, we shall have

$$\tan. \Delta = \frac{f}{m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Hence the magnetic force being constant, the tangent of the needle's deviation at the north or south will be a correct measure of the galvanic power."

"We have thus a principle by means of which we may verify a part at least of our theory by experiments. For example, since by the supposition every particle of the galvanic vertical wire acts inversely as the square of its distance from a given point, we ought to find a determined relation between the tangent of deviation and the length of the wire; or the length of the wire remaining constant, between the tangent of deviation and the distance, provided always that the intensity of the battery remain constant."

"The apparatus already explained furnishes us with the opportunity of making both these comparisons. For by means of the sliding horizontal rods, the vertical conducting part of the wire may be shortened in an instant; and, in the second case, it is only necessary to slide up the compass to different distances, which may likewise be done so quickly, that it will not be necessary even to have recourse to the standard compass."

"It is fortunate also that the calculation here alluded to is of the simplest kind. For denoting the length of the wire by $2l$, and the distance of the compass by d; assuming also x as any variable length, the corresponding elementary action at this distance will be $\frac{x}{d^2 + x^2}$, and the sum of these actions will be

$$\int \frac{x}{d^2 + x^2} = \frac{1}{d} \text{ arc. tan. } \frac{x}{d},$$

which vanishes when x vanishes; and which, therefore, when $x = l$, and the two lengths are included, becomes $\frac{2}{d}$ arc. tan. $\frac{l}{d}$, consequently if we denote the deviation, as we have done above by Δ, we ought to find this force vary inversely as tan. Δ, or,

$$\cot. \Delta \left\{\frac{l}{d} \text{ arc. tan. } \frac{l}{d}\right\} = \text{a constant quantity.}$$

"The following are a few out of numerous experiments of this kind which I have made, and which have been all found equally satisfactory.

"*Experiments to determine the Magnetic Deviation caused by a galvanic vertical Wire at different Distances. Length of vertical Wire 36 Inches.*

Deviation by standard compass.	Distance of the other compass from the wire.	Mean * observed deviation Δ.	Value of $\frac{2}{d}$ arc. $-$ tan. $\frac{l}{d} = A$.	Constant product. A cot. Δ
25° 0′	12 inch.	5° 37′	18·772	190880
Ditto	8	11 15	34·100	171432
Ditto	6	16 30	47·712	161062
Ditto	4	26 30	77·500	154440
			Mean	164728

"When it is considered that these observations were made on a compass needle only one inch in length, and that the divisions extended only to quarter points, it is impossible to expect a closer approximation. The needle and card, however, being delicately suspended, and the latter very distinctly divided, I could depend upon my observations to the nearest *degree*; for by means of a strong magnifying power I could always bisect and trisect the quarter points without any very sensible error."

Mr. Barlow next gives some *experiments to determine the magnetic deviation caused by a vertical galvanic wire; the length being varied, but the distance constantly nine inches*; and having thus far verified his hypothesis by experiment, he proceeds to the consideration of the deviation in different azimuths; but as the limits to which we are confined will not allow us to follow him, we must terminate our notice of the section with some of his concluding remarks.

"My results," he says, "are necessarily only approximate; because I have throughout supposed the needle indefinitely short in comparison with the distance and length of the wire; but by this means I have rendered the subject perfectly intelligible to every one; whereas had I taken the actual case of the reciprocal action of every particle of the fluid in the wire upon every particle in the needle, and had been able to complete the investigation, it could only have been understood by a few mathematicians; at the same time the minute corrections thus introduced would not have been appreciable in the comparison of the results with experiments; these latter being necessarily both liable to small irregularities, and difficult to observe."

"It will have been noticed that I have only attempted to illustrate the nature of the action which has place between a gal-

* "That is, the mean of two observations at each station of the compass; the contact being changed. The same is to be understood of the deviation with the standard compass."

vanic wire and the compass, and not that of one galvanic wire on another. What modification the hypothesis may require to explain the latter class of phenomena, will be examined hereafter. I have hitherto supposed only one species of action in the galvanic wire, but it is highly probable that it is compound, and that while the north end of the needle is carried in one direction by the action we have supposed, the south end is carried in an opposite direction; not merely as a consequence of the first force, but by a distinct power. This will not, however, in any respect, affect our investigation; because both forces lead to similar results. . . . . . I am well aware of the difficulty of conceiving the mechanical principles by which such a tangential force, as is here assumed, can operate; but, on the other hand, it must, I think, be conceded, that the simple power of attraction is equally difficult to conceive, and that we admit it, not from having any idea of the *modus operandi*, but because we find that it leads to results that are consistent with actual observations; and I have endeavoured to show, in the preceding pages, that the force we have assumed is admissible upon precisely the same ground."

The third section of this part contains a course of electromagnetic experiments, "due to the several ingenious philosophers who have interested themselves in this pursuit;" and in which Mr. Barlow endeavours "to show their mutual dependencies on each other, and their general agreement and particular connection with the mathematical theory advanced in the second section."

These are succeeded by addenda to Sect. 12 and 13, Part I. "On the Magnetic Effects of Iron Masts on the Compass," which terminate this valuable work, and from which it appears, that the contemplated employment of hollow iron masts in ships of war, in lieu of those at present in the service, will be productive of no disturbance on the compass, under any circumstances, but what may readily be corrected by the method Mr. Barlow has proposed.

Article XII.

Proceedings of Philosophical Societies.

ROYAL SOCIETY.

April 17.—On the Application of the Liquids produced by the Condensation of Gases as Mechanical Agents. By Sir H. Davy, Bart. PRS.

It is well known that the elasticity of vapours in contact with the liquids from which they are produced at high temperatures, increases in a much higher ratio than the arithmetical progres-

side of the temperatures; but the great liberation of latent heat by compression, and its absorption by expansion, seem to render the mechanical application of them at temperatures greatly elevated above the boiling points of the respective liquids of doubtful economy. No doubt, however, in this respect, observed the President, can be entertained of those vapours which can only be produced under high pressures, and at common temperatures. To illustrate this subject, Sir Humphry described the results of some experiments on the increase of elastic force in the vapours of several of the condensed gases; one of them, that of liquid sulphuretted hydrogen, which exerts a pressure of 14 atmospheres at 3°, becomes equal in pressure to 17 atmospheres at 47°.

Among other experiments described in this communication, were some in which the author had liquefied prussic gas and sulphurous acid gas, by confining them with a portion of ether in glass tubes over mercury, and then raising the ether in vapour:—as this vapour condensed, the liquefied gas resumed its aeriform state, and cold was produced.

Sir Humphry concluded with some remarks on the probable applications in the arts of the condensed gases; among which, besides their employment as mechanical agents, he suggested those of impregnating water with large quantities of carbonic acid and other gases, without the aid of mechanical pressure; and the ready production of cold, in consequence of the rapidity with which they evaporate.

At this meeting a paper was also read, On the Temperature, at considerable Depths, of Fresh-water Lakes, within the Tropics. By Capt. Edward Sabine, FRS. in a letter to the President.

Sir H. Davy had requested Capt. Sabine, while engaged in his late observations in the tropical regions, to make some experiments on the temperature of deep lakes, with a view of obtaining facts in illustration of that interesting object of inquiry, the temperature of the interior of the earth; no opportunity of instituting such researches had, however, occurred to him, but he had made one experiment on the subject, in a part of the Carribean Sea, which, from its confined situation, nearly resembled a lake; and this experiment he proceeded to describe, from the original memorandums of it.

At the period of this experiment, Capt. Sabine was on board one of his Majesty's vessels, in lat. 20° 30′ N. and long. 83° 30′ W., between the Caymans, and Cape St. Antonio, in the Island of Cuba. The weather was fine, with light airs, and the sea not swelling in a great degree. To the bottom of a line of above 1200 fathoms, a strong iron cylinder was fastened, the top of which screwed down upon leather in order to prevent the entrance of the water, by the compression of which in the cylinder the temperature might be raised: within the cylinder was a Six's self-registering thermometer, prevented, by means of springs

from coming into immediate contact with its sides. Above this closed cylinder was fastened another, full of perforations, to allow the water free passage through it, and likewise furnished with a thermometer. The line was let out in twenty-five minutes, and, by the lowest estimation, 1000 fathoms, or 6000 feet, was the perpendicular depth to which the cylinders descended: it was drawn back in fifty-three minutes, when, owing to the circumstance that the top of the closed cylinder had not been screwed down sufficiently upon the leather, the sea was found to have entered it; in this, the thermometer marked 49·5°, and that in the perforated cylinder 45·5°; the temperature of the surface of the sea was from 82° to + 83°, so that the difference of its temperature there, and at the depth above-mentioned, amounted to + 37°.

Capt. Sabine inferred from this result, that at a depth little exceeding that at which the experiment was made, the sea-water would be found to have attained its greatest density, supposing that point to be, as in fresh-water, a few degrees above the freezing point. He terminated the communication by some remarks on an experiment made by Peron, the result of which, as far as it was satisfactory, agreed with his own.

At this meeting, likewise, the reading was commenced of A Continuation of Prof. Buckland's Account of the Bones discovered in Caves in various Parts of England.

April 24.—An Account of Experiments made to determine the Length of the Invariable Pendulum at various Places on the South American Station. By Capt. Basil Hall, FRS. in a letter to Capt. Kater, FRS.

The places at which Capt. Hall had ascertained the Length of an Invariable pendulum belonging to the Board of Longitude, as detailed in this paper, were the following: The volcanic island of Abingdon, one of the Gallapagos; the sea-port of San Blas on the coast of Mexico; and Rio de Janeiro on the coast of Brazil. He stated, among various other circumstances, that he had unsuccessfully endeavoured to simplify Capt. Kater's method of determination; and he intimated that he purposed to make some experiments on the actual effects of heat upon the pendulum, independently of all theoretical considerations.

May 1.—On the Expansion by Heat of Gases in various States of Condensation and Rarefaction, being an Appendix to a former paper on the Application of the Gases, condensed into Liquids, as Mechanical Agents. By Sir H. Davy, Bart. PRS.

The experiments of MM. Gay-Lussac and Dalton have shown, that the gases expand equally for equal increments of heat, at all temperatures between 32° and 212°; but the President was not aware that any direct experiments had been instituted with the view of determining whether the same law prevailed with regard to the respective aeriform bodies at different

ent degrees of density; and had, therefore, been induced to make some researches on the subject. A portion of atmospheric air was heated in a glass tube from 32° to 212°, and the space which it then occupied accurately marked; the experiment being made with air, confined by the pressure of 30 and 65 inches of mercury, it was found to occupy the same space as the air under common pressure; the same result was obtained when the air was six times condensed, and also when it was once, twice, thrice, and fifteen times rarefied.

At this meeting, the reading of Prof. Buckland's paper, which had been begun on the 17th of April, as above stated, was resumed and concluded.

Mr. Buckland had mentioned, at the end of his former paper that another cave, similar to the one he had examined at Kirkdale, had been discovered at Kirby Moorside, and that it had been closed up by the proprietor C. Duncombe, Esq. until some qualified person should be present to inspect it in its undisturbed state. The author went into Yorkshire to examine it, last July, in company with Sir H. Davy and Mr. Warburton; and though it contained not a single bone, yet its circumstances with respect to diluvial sediment and stalagmite were precisely analogous to those of the cave at Kirkdale, and fully confirmed his account of, and reasoning upon them. The second part of this paper related to a fissure of postdiluvian origin in Duncombe Park; the existence of which had not been known to Mr. Duncombe until the author's late visit. It lies open, like a pit-fall (partially concealed by bushes), across the top of a limestone hill on the west side of the valley of the Rye; its direction is oblique, and it has several ledges, at different depths, and various irregular lateral openings. It contains neither mud nor pebbles, but upon the ledges lay the dislocated skeletons of various animals that had recently fallen in and perished; comprising those of dogs, sheep, deer, goats, and hogs, &c. They were not imbedded in loam or covered with stalactite; the bones did not adhere to the tongue; retained much of their animal matter; and were evidently much more recent than those found in the cave at Kirkdale.

From the circumstances of this fissure and its contents, Prof. Buckland proceeded to illustrate the origin of the assemblages of bones in the Plymouth and other fissures and caves connected with them. The number of such fissures which are met with, filled with diluvian detritus, he observed, evinces that open fissures must have been more numerous in the antediluvian state of the earth than at present; and as it is the habit of graminivorous animals to be constantly traversing the ground, in all directions, in the act of cropping their food, they would often be liable to fall into them, and actually do so in Derbyshire, and the limestone districts of South Wales; while carnivorous animals

would, from their different habits, be less exposed to such accidents; and this circumstance affords a probable reason why the bones of the latter are less abundant in fissures than those of the former class of animals.

In the third section of this communication, Mr. Buckland described the caves discovered at Plymouth in 1822, referring to Mr. Whidbey's account already before the Society (and reported in the *Annals* for March, p. 233—235): the Plymouth caves consisted of fissures traversing the rock in all directions, some vertical, some oblique; and the reason why several of them appeared at first to Mr. Whidbey to have had no communication with the surface, was, that they were first opened at their lower extremity, where they ended in a cul de sac, and traversed the rock so obliquely as not to reach the surface, but at a distance from the working face of the quarry. A cave discovered at Wirksworth, in Derbyshire in Dec. 1822, containing the entire skeleton of a rhinoceros, and the bones and horns, &c. of deer, and another at Paviland, near Swansea, containing bones of the elephant, rhinoceros, bear, hyæna, wolf, ox, horse, and a human female skeleton, with various indications of human habitation, were likewise described; and the paper concluded with an examination of several hypotheses by which the phenomena of the various assemblages of animal remains adverted to, might be explained, showing, that the only satisfactory manner of accounting for the presence of the mud and pebbles, is to attribute them to diluvial origin; and that with regard to the bones, they must be divided into five classes.

1. Those of carnivorous animals that retired spontaneously to the caves to die during successive generations in the period immediately preceding the deluge, as in the case of the bears' bones in the caves of Germany.

2. The remains of animals that were dragged in as food by beasts of prey during the same period, as in the case of the various remains in the cave at Kirkdale.

3. The remains of animals that fell into and perished in the open fissures and caves connected with them in the period preceding the deluge, as in the case of the bones at Plymouth and Gibraltar.

4. The remains of animals that were washed in together with the mud and pebbles at the deluge, as in the case of the entire skeleton of a rhinoceros, near Wirksworth.

5. The remains of animals that have entered caverns or fallen into open fissures since the period of the deluge, as in the case of the human bones in the open cave at Paviland, and the bones of dogs, deer, &c. in the open fissure at Duncombe Park.

May 8.—At this meeting, Prof. Oersted attended, and was admitted a foreign member of the Society; and he was justly complimented by the President on his brilliant discovery of the

magnetic effects of electricity, for which the Society had already awarded him the Copleyan medal.

The reading of Prof. Buckland's Account of Bones discovered in Caves and Fissures in various Parts of the Continent, was commenced.

May 15.—At this meeting, the reading of Prof. Buckland's paper was resumed and concluded.

Mr. Buckland examined the caverns alluded to in the summer of 1822, and found that all their characters and phenomena confirmed his former conclusions respecting them and the English caves: they all contain either diluvian mud, or diluvian sand and pebbles, covered with one coat of stalagmite only; the bones are imbedded in the mud, &c. and are often united with it by the infiltration of stalagmite, into an osseous breccia, resembling that of Gibraltar and the coasts of the Mediterranean. The caverns are in limestone rocks of different ages and formations, and all their circumstances concur to show that the bones they contain had existed in them previously to the inundation by which the mud and pebbles were introduced.

The cave at Scharzfeld, in Hanover, on the west border of the Hartz Forest, is in magnesian limestone analogous to that of Sunderland, being the first floetz limestone of Werner; it is situated at the elevation of 500 feet above the level of the nearest river, and it consists of one large chamber, with numerous smaller lateral connexions. Its floor of stalagmite has been much broken up by visitors in search of bones and teeth of bears and hyænas, but principally of bears. The lower cavities and under vaultings of this cavern have been wholly filled up with a mass of mud, pebbles, and bones, in which artificial excavations have been made for the purpose of extracting the bones, and it is only in these artificial cavities that any bones or teeth are found adhering to the sides or roof. In one of the smaller cavities, Prof. Buckland found the fractured head of a bear imbedded in mud, and having a large pebble lodged in the cavity of the skull.

The Bauman's cave situated on the north-east side of the Hartz, near Elbingrode, is so called from a miner, who, in 1670, went into it in search of ore, and having wandered about in it three days and nights, came out, so exhausted, that he almost immediately expired. It is in transition limestone, and is elevated about 100 feet above the river Bode, and as that river could not rise ten feet without inundating the adjacent village of Rubeland, the mud, &c. which the cave contains could not have been deposited by the floods of the river. This cavern contains a great quantity of large pebbles. The bones in it are partly imbedded in loose sand and mud, and partly united with the large pebbles into a solid breccia. Those in the breccia have been much broken, and some of them crushed to pieces (as if

into mortar) by the movement of the heavy pebbles to which the crushed fragment still adheres united by stalagmite. The bones that lie in mud and sand in the same vault have not been thus broken. Over the whole there is a crust of stalagmite, like that in the other caverns.

The general aspect and state of the bones in all these caverns, and the circumstances attending them, are very similar to those the author had observed in cavernous fissures at Plymouth.

The caves in Franconia are situated in an elevated tract of land which forms one of the central water-heads of Europe, near the sources of the Mayn and Naab, and between the towns of Nuremberg, Bareuth, and Bamberg. They are in a bed of limestone locally called höhlen kalk (hole limestone), being a variety of the Jura limestone, or younger alpine limestone of the Continent.

This district is full of caverns, many of which are crowded with bones (principally of bears), while others are wholly destitute of them; but in all, there is an accumulation of diluvial sediment covered for the most part with a single crust of stalagmite. Those selected for description are the caves of Forster's Hole, Rabenstein, Zahnloch, Gailenreuth, and Kühloch. The author has attended particularly to the evidences of diluvial action within them all, and finds that in each case the mud and pebbles were superinduced upon the bones of animals which had died and become accumulated in their dens in the antediluvian period when wild beasts inhabited these countries. Forster's Hole is most remarkable for the beauty of its stalagmite and roof. In Rabenstein, the bones and mud have been but little disturbed. From Zahnloch they have been extracted for centuries, and used under the name of bones of the licorne, or fossil unicorn, for imaginary medical virtues. In this cave there is a block of stone which is polished, apparently by friction from the skin and paws of the antediluvian bears. At Gailenreuth, there is an accumulation of bony breccia 30 feet deep or more, as the bottom has not yet been penetrated; and in Kühloch, so great a mass of black animal earth with bones dispersed through it, that, allowing two cubic feet of matter for the exuviæ of each individual, this single cave must contain the remains of at least 2500 bears, a number which may have been supplied in 1000 years by a mortality of two and a half per annum. The cave in which this singular mass is found was probably the lowest part of a large and connected series of caverns inhabited by bears, and into which, during successive generations, these animals retired to die. The animal matter covers the entire floor to the depth of about six feet, which, being multiplied by the length and breadth of the cave, shows the total quantity to be not less than 5000 cubic feet: the bones and teeth dispersed through this dust are much decayed, and readily crumble into the same dark umber-coloured powder as that which forms the greater

part of the matrix in which they are imbedded. In this cave there is no stalagmite, neither are there any pebbles; its animal earth also is peculiar, but the author points out in its situation and circumstances sufficient causes to account for these apparent anomalies.

Professor Buckland concluded this communication with some general remarks on the caves in Germany, among which were the following: 1. The present entrances to them were not their original openings, but are only truncated portions of their lower branches laid open by diluvial denudation: 2. The diluvium they contain is either loam, sand, or pebbles, but more commonly a mixture of all three, through which the bones lie interspersed, and the whole mass has often been indurated into an osseous breccia, like that of Gibraltar. 3. The loam has not been produced by the decay of the flesh or bones, or of the rock in which the cave exists, but it agrees, in chemical constitution, with that of the diluvial beds of the adjacent country. 4. The number of caves in which any bones at all are found, is comparatively very small, but where they occur it is usually in enormous quantities. 5. Every circumstance tends to evince, that the mud, pebbles, &c. were washed in by the deluge upon the bones already existing in the caves: if, on the contrary, all the bones had been drifted in by the diluvian waters, they would be found dispersed in small quantities only, and in numerous caves. 6. There is only one superficial crust of stalagmite in any of the caves, and no alternations of mud, pebbles, and bones, but simply one confused mass covered by a single crust of stalagmite. 7. The identity of the period in which the animals lived whose remains occur in caves, fissures, and diluvial gravel or loam, is shown by the agreement of the species of animals whose remains they contain; since it appears that the extinct hyæna, bear, elephant, and rhinoceros, occur, with many other animals, in diluvial gravel beds, as well as in caves; while the extinct tiger is found, together with the remains of horses, oxen, deer, &c. in fissures and caverns, as well as in superficial beds of diluvial gravel. The period also in which the animals lived, whose remains are found in the breccia of Gibraltar, is shown to be the same as that in which the hyænas inhabited the den at Kirkdale, and the bears the caves of Germany, viz. that immediately preceding the deluge. 8. The author concludes that the inundation which destroyed these animals was transient and universal; that it also covered the highest mountains; and that it took place at a period which cannot have exceeded a few thousand years ago. To these are added some important examples of the effect of the diluvian waters in the excavation of valleys, and of the accumulations of diluvial gravel in Britain, and in other parts of the world.

At this meeting, the reading of the following paper was also commenced, and the completion of it postponed to another

meeting:—An Account of a Magnetic Balance, and of some Experiments on Magnetism recently made with it. By William Snow Harris, Esq. Communicated by the President.

In consequence of the approaching festival, the Society then adjourned over one Thursday, to meet again on the 29th of May.

LINNEAN SOCIETY.

April 1.—Remarks on a Minute Luminous Insect frequently observed in the course of a voyage to India. By Major-Gen. Hardwicke, FLS. &c.

This insect, to which the author would not venture to give a name, is three lines in length, by one and a half in width; is oblong, ovate, depressed, and so thin as to be semitransparent: it consists of nine segments, which are all provided with hairy tufts, apparently legs; the first segment contains the head and the thorax. After being taken up from the sea, it remained luminous for an hour, in a bucket of salt-water; and, for some minutes, in the hand. Some of the small *cancri* are luminous, as well as some of the *onisci;* Gen. Hardwicke considers that the insect above described approaches more to the former genus than to the latter one.

At this meeting, the reading of the following paper was commenced:—Commentary on the second Part of the Hortus Malabaricus. By Francis Hamilton, MD. &c.

On *April* 15, and *May* 6, the reading of Dr. Hamilton's paper was continued.

GEOLOGICAL SOCIETY.

May 2.—A paper was read, on the Geology of Upper Canada.

A notice was read, on the Discovery of a large Fossil Elephant's Tusk, near Charmouth, Dorset. By H. T. de la Beche, Esq. MGS.

A paper was read, entitled, "Observations on the Genus Actinocamax." By J. S. Miller, Esq. ALS.

A paper was read, on the Belemnites of the Chalk and alluvial Strata of Norfolk and Suffolk, with Notices on their Localities, and accompanying Fossils. By Richard Taylor, Esq.

May 16.—A memoir was read, on the Geology of Southern Pembrokeshire, from the observations of H. T. de la Beche, Esq. FRS. FLS. MGS. and the Rev. W. D. Conybeare, FRS. MGS. &c. Drawn up and communicated by the former.

This memoir is accompanied by a map, and extensive sections of the coast. The constituent formations occurring in this district are as follows, beginning with the lowermost: 1. Trap. 2. Greywacke. 3. Old red sandstone. 4. Carboniferous limestone. 5. Coal measures.

Article XIII.

Scientific Intelligence, and Notices of Subjects connected with Science.

I. *Action of Phosphorus and Water.*

It is well known that when phosphorus is kept in water, the sticks, although at first transparent, are covered with a white opaque crust, which eventually becomes of a reddish-yellow colour.

Wishing to determine the nature of this change and the circumstances by which it is accelerated or retarded, I placed translucent sticks of phosphorus in two vials nearly filled with distilled water. One of the vials was exposed to day-light, and occasionally to the direct rays of the sun. In a few hours, that side of the cylinder of phosphorus which was exposed to the light became opaque, and the water acquired a peculiar smell. On putting litmus paper into the water, it became of a red colour, indicating the presence of an acid, and which was probably the phosphorous acid, or a mixture of that and the phosphoric: this I did not determine. I now added some of the water to solution of nitrate of silver, and another portion to solution of protonitrate of mercury; in both cases, a dark-coloured precipitate was formed, which is a well-known characteristic of the presence of phosphuretted hydrogen. By exposure to air, the solution loses its power of giving a dark-coloured precipitate with silver and mercury, owing partly to the evaporation of the phosphuretted hydrogen, and probably more to its conversion into phosphoric acid and water by absorbing oxygen. After nearly a month had elapsed, I examined the pieces of phosphorus which had been excluded from the action of the light; the water in which they had been immersed was slightly acid, and gave indications of the presence of phosphuretted hydrogen in a slight degree; the action, however, which had taken place was so trifling that the transparency of the phosphorus was scarcely at all diminished.

From this statement, it is evident, that phosphorus has the power of decomposing water; that oxide of phosphorus is first formed, and eventually phosphorous or phosphoric acid; and that the hydrogen of the water forms phosphuretted hydrogen, with a portion of the phosphorus; and, lastly, that these effects are much accelerated by the action of light.—*Edit.*

II. *Phosphate of Uranium.*

In the *Annals* for January last, I gave an analysis of the green uranite from Cornwall, and I stated my reasons for supposing that the uranite from Autun, which has the same crystalline form as the Cornish, was also a phosphate of uranium. Mr. Heuland having had the kindness to present me with some of the French uranite, I subjected it to examination, and found, as I had supposed, that it is a phosphate. Joseph Carne, Esq. of Riviere, has also been so good as to supply me with a new variety of the uranite from Cornwall; this, instead of being crystallized in square plates, and of a green colour, is composed of fibres radiating from a centre; this I also submitted to examination, and found it to be similar to the specimens above alluded to.—*Edit.*

III. *On the Question as to the Existence of Metallic Veins in the Transition Limestone of Plymouth.* By the Rev. Richard Hennah.

(To the Editor of the *Annals of Philosophy.*)

SIR, *Citadel, Plymouth, May* 13, 1823.

I have been prevented by illness and other circumstances from attending so early as I wished to your note annexed to my letter, on *the subject of metallic veins in the Plymouth limestone,* inserted in the 28th number of the *Annals of Philosophy.*

I have called on Edmund Moss at Cat-Down this day, not with a view to remove any doubts on the subject existing in my own mind, for there were none, so much as to satisfy your correspondent on the point in question. In answer to my inquiries, he said, that he had worked in the lime-quarries at Cat-Down and the neighbourhood upwards of 40 years, and had never observed any mineral whatever, or quartz, in mass in any of them. He recollects, however, selling some time ago to a dealer in Plymouth, a few specimens from the lime, and, among them, one or two from the vicinity of Tavistock; but that the latter were totally different from any thing we had in our quarries.

I have also asked several other quarrymen, some of whom have been so employed for 12 or 15 years, whether they ever met with, in their workings, any veins of any of the metals, or quartz in quantity among the limestone of Plymouth? To which *they have invariably answered, No,* and seemed to wonder at *my asking such a question,* as at a thing never heard of.

I shall feel obliged, therefore, by your inserting the above, not only for the purpose of satisfying your correspondent, but because it may also be not unacceptable to your numerous readers in general.

I remain, Sir, your obedient servant,

RICHARD HENNAH.

ARTICLE XIV.

NEW SCIENTIFIC BOOKS.

PREPARING FOR PUBLICATION.

Mr. E. W. Brayley, Jun. is preparing a work on The Natural History of Meteorites, or of those remarkable masses of iron and of earthy and metallic compounds, which, at different periods, have fallen from the atmosphere, as well in England, as in many other countries; including remarks on their probable origin. With a Historical Introduction, showing that the worship of them was widely prevalent in former ages, and that it still continues in certain Pagan countries; and an Appendix of Tables, &c. In 1 vol. 12mo. illustrated by Plates and Diagrams.

Mr. J. F. Daniell has in the press a volume of Meteorological Essays.

Mr. Patrick Syme is preparing a work on British Song Birds, to be illustrated with 15 coloured Engravings.

A New Edition of Dr. Gordon's Forensic Medicine, which will contain an accession of much valuable matter.

Another Edition also of Mr. T. Peckston's work on Gas-Lighting will shortly appear, and will contain several alterations, and considerable additions.

Mr. T. Tredgold is about to publish an Essay on the Principles and Practice of Heating by Steam.

Illustrations of the Mode of maintaining Health, curing Diseases, and protracting Longevity, by Dr. Forster, will shortly be published.

In the press, Practical Remarks on Fractures at the upper Part of the Thigh, and particularly Fractures within the Capsular Ligament, by Mr. Earle.

Mr. R. Meikleham has in the press, A Practical Treatise on the various Methods of heating Buildings by Steam, Hot Air, Stoves, and open Fires.

JUST PUBLISHED.

Medical Jurisprudence, comprehending Medical, Chemical, Anatomical, and Surgical Investigations applicable to Forensic Practice; for the Instruction and Guidance of Coroners, Magistrates, Barristers, and Medical Witnesses. With a copious Appendix of Statutes, Cases, and Decisions. By John Ayrton Paris, MD. FRS. FLS. and John Fonblanque, Esq. Barrister-at-Law. 3 Vols. 8vo. 1*l*. 16*s*.

The Geography and History of America and the West Indies; exhibiting a correct Account of the Discovery, Settlement, and Progress, of the various Kingdoms, States, and Provinces of the Western Hemisphere, to the Year 1822. Illustrated by several coloured Maps, Charts, and Views. 8vo. 18*s*.

An Exposition of the Principles of Pathology, and of the Treatment of Diseases. By Daniel Pring, MD. 8vo. 14*s*. Boards.

Elements of Pharmacy, and of the Chemical History of the Materia Medica. By Samuel Frederic Gray, Lecturer on the Materia Medica, &c. 8vo. 10*s*. Boards.

Article XV.

NEW PATENTS.

P. Chell, of Earle's-court, Kensington, Middlesex, engineer, for certain improvements on machinery for drawing, roving, and spinning hemp, flax, and waste silk.—Feb. 18.

A. Applegath, of Duke-street, Stamford-street, Blackfriars, Surrey, printer, for certain improvements in printing machines.—Feb. 18.

T. Bury, of Salford, Manchester, dyer, for improvements in dyeing or producing a permanent nankeen colour on cotton, wool, skein-yarn, and certain other articles.—Feb. 18.

F. Deakin, of Birmingham, sword-maker, for improvements in pianofortes, and other stringed instruments.—Feb. 18.

W. Church, of Nelson-square, Surrey, gentleman, for an improved apparatus for printing, to be used by type, block, or plate printers.—Feb. 18.

Article XVI.

METEOROLOGICAL TABLE.

1823.	Wind.	Barometer. Max.	Min.	Thermometer. Max.	Min.	Evap.	Rain.	Daniell's hyg. at noon.
4th Mon.								
April 1	S W	30·16	29·86	66	46	—		
2	S W	29·90	29·86	56	39	—	02	
3	W	29·90	29·54	52	44	—	15	
4	N W	29·54	29·18	54	43	—	22	
5	N W	29·29	29·18	55	39	—	35	
6	N W	29·83	29·29	47	40	—	18	
7	N	29·98	29·83	53	30	—	07	
8	N E	29·98	29·93	51	38	—		
9	N E	30·21	29·93	56	31	—		
10	E	30·32	30·21	55	29	—		
11	E	30·30	30·28	56	25	·81		
12	N E	30·28	30·23	46	30	—		
13	N E	30·23	30·22	50	39	—		
14	E	30·45	30·22	52	39	—	—	
15	Var.	30·46	30·29	56	35	—		
16	W	30·29	30·10	56	46	—	02	
17	N W	30·10	29·75	64	40	—		
18	N W	29·75	29·60	55	33	—	—	
19	N W	30·01	29·62	50	28	—	05	
20	N W	30·07	30·01	50	35	—		
21	S W	30·01	29·93	50	28	·82		
22	E	29·93	29·54	60	39	—		
23	E	29·65	29·40	60	42	—	24	
24	N E	29·99	29·65	55	30	—		
25	S W	29·99	29·84	55	44	—	08	
26	S E	30·10	29·84	53	36	—	43	
27	N E	30·28	30·10	54	27	—		
28	N W	30·35	30·28	55	34	—		
29	N E	30·53	30·35	60	30	—		
30	S E	30·53	30·49	65	30	·72		
		30·53	29·18	66	27	2·35	1·81	

The observations in each line of the table apply to a period of twenty-four hours, beginning at 9 A. M. on the day indicated in the first column. A dash denotes that the result is included in the next following observation.

REMARKS.

Fourth Month.—1. Fine. 2. Cloudy: windy. 3. Morning fine: rain in the evening. 4, 5. Rainy. 6. Cloudy. 7. Showery. 8. Cloudy. 9—11. Fine. 12, 13. Cloudy. 14. Cloudy: a few drops of rain. 15, 16. Cloudy. 17. Fine. 18. Fine: a shower of hail about noon. 19. Fine: a shower of hail about four, p.m. 20. Fine: wind cold. 21, 22. Fine. 23. Cloudy. 24, 25. Fine. 26. Rainy. 27. Fine. 28. White frost in the morning. 29. Fine. 30. White frost, with fog in the morning.

RESULTS.

Winds: N, 1; NE, 7; E, 5; SE, 2; SW, 4; W, 2; NW, 8; Var. 1.

Barometer: Mean height

For the month	29·982 inches.
For the lunar period, ending the 3d	29·964
For 14 days, ending the 8th (moon south)	29·900
For 13 days, ending the 21st (moon north)	30·110

Thermometer: Mean height

For the month	45·483°
For the lunar period	42·266
For 31 days, the sun in Aries	45·096

Evaporation	2·35 in.
Rain	1·81

Laboratory, Stratford, Fifth Month, 24, 1823. R. HOWARD.

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W.

THE END.

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